

Vitruvius'

On Architecture

Translated by Frank Granger

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VITRUVIUS ON ARCHITECTURE

I

VITRUVIUS

ON ARCHITECTURE

EDITED FROM THE HARLEIAN MANUSCRIPT 2767 AND
TRANSLATED INTO ENGLISH BY

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IN TWO VOLUMES

I



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PREFACE

THIS edition has been based upon the oldest MS. of Vitruvius, the Harleian 2767 of the British Museum, probably of the eighth century, and from the Saxon scriptorium of Northumbria in which the Codex Amiatinus was written. The Latin closely resembles that of the workshop and the street. In my translation I have sought to retain the vividness and accuracy of the original, and have not sought a smoothness of rendering which would become a more polished style. The reader, it is possible, may discern the genial figure of Vitruvius through his utterances. In a technical treatise the risks of the translator are many. The help of Dr. Rouse has rendered them less formidable, but he is not responsible for the errors which have survived revision.

The introduction has been limited to such considerations as may enable the layman to enter into the mysteries of the craft, and the general reader to follow the stages by which the successive accretions to the text have been removed. The section upon language indicates some of the relations of Vitruvius to Old Latin generally.

My examination of fourteen MSS. has been rendered possible by the courtesy of the Directors of the MSS. Libraries at the British Museum, the Vatican, the Escorial, the Bibliothèque Nationale

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at Paris, the Bodleian, St. John's College, Oxford, and Eton College. A word of special thanks is due to his Excellency the Spanish Ambassador to London, his Eminence the Cardinal Merry del Val and the Secretary of the British Embassy at Paris, for their assistance.

Mr. Paul Gray, M.A., of this College, has given me valuable help in preparing the MS. for the press.

FRANK GRANGER.

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NOTTINGHAM,
September, 1929.

INTRODUCTION

VITRUVIUS AND THE ARCHITECTURE OF THE WEST

THE history of architectural literature is taken by Vitruvius to begin with the theatre of Dionysus at Athens.¹ In earlier times the spectators were accommodated upon wooden benches. According to one account,² in the year 500 B.C. or thereabouts, the scaffolding collapsed, and in consequence a beginning was made towards a permanent stone structure. The elaborate stage settings of Aeschylus reached their culmination at the performance of the *Agamemnon* and its associated plays in 458. According to Suidas,³ the collapse of the scaffolding, which occurred at a performance of one of Aeschylus' dramas, led to the exile of the poet in Sicily, where he died in 456. In that case the permanent construction of the theatre would begin in the Periclean age some time between 458 and 456.

The performance of the *Oresteia* probably coincided with the first use of scene-painting. Agatharchus,⁴ an artist of Samos, who was employed upon this, introduced the method of perspective as a practical expedient, not only in scene-painting but elsewhere. His elder contemporary, Polygnotus,

¹ Vitr. VII., pref. 11.

² Suidas, s.v. Pratinas.

³ s.v. Aeschylus.

⁴ Vitr. VII., pref. 11.

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painted the figure without any light and shade and without a pictorial background. Agatharchus not only transformed the background of the stage, but changed the whole method of painting. He was followed by Zeuxis and Parrhasius. He left a notebook of a practical character, apparently a series of workshop recipes, with special reference to perspective. An illuminating anecdote recorded by Plutarch¹ connects the painter with the extraordinary speed with which the architectural schemes of Pericles were completed. Even the more simple applications of perspective would enable an artist to carry out designs with a rapidity, and on a scale, hitherto unknown.

The practical treatise of Agatharchus suggested to Anaxagoras and Democritus a theoretic treatment of perspective.² Since Anaxagoras belonged to the circle of Pericles,³ he forms one contact between the discoveries of Agatharchus and their application to the Parthenon. How far the subtle variations of the stonework in that building, from the horizontal and the vertical, are to be deduced from a system of perspective is a matter in dispute.⁴ We probably err in limiting ourselves to geometrical projection; the *logos opticos* or theory of vision including other considerations. At any rate, the authorities upon whom Vitruvius chiefly drew, Pythius and Hermogenes, often appeal to aesthetic principles, such as symmetry and congruity, which go beyond perspective.

If we take the Parthenon as furnishing a type of the Doric Order, Pythius in the fourth century at the Mausoleum and Priene, and Hermogenes in the

¹ *Pericles*, xiii.

² *Vitr.* VII., pref. 11.

³ *Plut. Pericles*.

⁴ *Lethaby, Greek Buildings*, p. 80.

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third century at Magnesia, supply guidance for the Ionic Order not only in the extant remains of their buildings but in the formal treatises upon which Vitruvius drew. Surprise has sometimes been expressed at the long list of authorities quoted by Vitruvius in the preface to his seventh book. There is, however, good reason to accept his statement that he selected from them what was suitable to the plan of his work. Some of his material may have come by way of Varro; the greater part seems to have been taken at first hand.

The descriptions left by architects of their buildings seem rather to have been in the form of specifications than like the formal treatises of Pythius and Hermogenes. We have not indeed the specification of the arsenal which Philo built in the Piraeus; but we have a recital of the works to be undertaken by the contractors,¹ which is a form of contract also, including something like a specification. To this were added the architect's drawings to scale. The general method of contracting with specification and drawings went back to what in Vitruvius' time was already antiquity. When the temple of Apollo at Delphi was burnt down in 548 B.C., it was rebuilt to the designs of a Corinthian architect, Spintharos, and with the funds of the Amphictionic League.² The contract was undertaken by the noble Athenian family of the Alcmaeonids. In order to gain the favour of the Delphic oracle, "they executed the work more splendidly than the plans of the architect showed, and in particular, whereas the building was to be of local stone, they carried out the front elevation in Parian marble."³ The contract was let to

¹ Dittenberger, *Sylloge IG*, 352.

² Paus. X. v. 13.

³ Herod. V. 62.

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the Alcmaeonids for 300 talents (£72,000), and the Amphictionic Council demanded from the city of Delphi a contribution of one quarter the amount. The citizens sent missionaries throughout the Greek world to aid in collecting the amount. They were especially successful in Egypt, where the native monarch gave a thousand talents of rock-alum (perhaps for use in making stucco), and the Greek settlers gave 20 minae (£80).¹ I have dealt at some length with the Delphic temple because it furnishes us with some notion of the earlier stages of Greek architectural practice. It also indicates the continuity of this tradition down to the point at which it is taken up by Vitruvius.²

We next turn to town-planning, which for Vitruvius³ begins with Alexandria and the architect Dinocrates. And yet Vitruvius might have found in Italy itself an older precedent. The export trade in pottery from Athens gave employment to a whole quarter of the city, the Ceramicus. A century before the sculpture of Athens became supreme in Greece, her pottery by its fine quality had gained a market in Etruria, Italy and Sicily. In order to secure her trade in the West, Athens determined to form an emporium in Southern Italy and employed the architect Hippodamus of Miletus to lay out the new city of Thurii. When the colonists arrived, they found their new home already partly built. In the time of Vitruvius, four centuries later, it was a cheerful watering-place.

To Vitruvius the main consideration in town-planning was to guard the thoroughfares against the prevailing winds. Consequently he shows a plan

¹ Herod. II. 180.

² Book VII., prof. 11.

³ Book I.; Book II., pref. 4.

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with the streets radiating from a centre. But his attempt to create a precedent failed. The Roman colonies in the main followed the lay-out of the Roman camp. It has been left to modern times to take up the Greek tradition. Washington is in the line of Thurii and Alexandria.

The form of Greek and Roman architecture was largely determined by the excellent stone and marble quarries which were at their command; just as Egyptian architecture is relevant to the noble igneous rocks of the Nile valley. We have seen Parian marble exported to Delphi. Athens was near the quarries of Pentelicus, Roman buildings were faced with stone from Carrara. Alongside with marble and stone was the use of burnt or sun-dried brick. The latter continued in Rome till the end of the Republic. The use of burnt brick was customary in Babylon and in regions under Babylonian influence; at Halicarnassus glazed brick also seems to have been used in the fourth century.¹ It was not until the Empire that burnt brick came into use at Rome. The most impressive features of Roman building, the arch and the vault, are associated with this material.

It is at this stage that Vitruvius appears with this treatise. We know almost as much about Vitruvius as we know about Shakespeare. Vitruvius was interested in himself, and informs the reader that he was neither good-looking nor tall. He sought consolation in writing. And familiarity with his treatise gains respect for the writer. Purists may regret his deviations from the canons of Cicero. A deeper feeling will be aroused by the vernacular character of his Latin, which is faithfully recorded by the

¹ Vitr. II. viii. 11.

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oldest extant MS. *H.* The Latin of the mason's yard and the carpenter's bench and of Vitruvius' text-book was to be echoed all over Western Europe in the early part of the Middle Ages.

But Vitruvius was the channel of the tradition of science. Greek philosophy in his pages was the coryphaeus of mathematics and the special sciences. For Vitruvius himself seems to have spoken Greek, and to have had a direct acquaintance with Greek literature. In this respect he was, none the less, Roman. Greek began two centuries before Christ to replace Latin as the language of Roman society. It flowed from the dying lips of Caesar. A century later it conveyed to the already venerable church of the capital the masterly exposition of Christian principles by St. Paul, a Semite and a Roman citizen. The affinity of the Western Church with Vitruvius is deeply rooted indeed if we follow the oldest reading,¹ "let no one think I have erred if I believe in the *logos*." "*Ne putet me erravisse si credam rationem.*" At any rate this manual combines a scientific temper with a rational respect for the numinous.²

Vitruvius held an official position in the rebuilding of Rome by Augustus.³ His treatise, however, never mentions Octavian by his official name Augustus, and presumably was written before 27 B.C., when it was conferred. The Roman plumbers, according to Frontinus, seem to have acted on his instructions in determining the size of their lead pipes.⁴ We can perhaps trace in Pliny⁵ a reference to the standards imposed by Vitruvius. More general is the use of

¹ *H.* II. i. 8.

³ Cf. I., pref. 2.

⁵ *N.H.* xxxi. 68.

² *Numen* = "a divine gesture."

⁴ Front. *Aquaed.* 25.

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Vitruvius made by the same writer, showing that the manual of Architecture was already a standard work. This tradition lasted as far as Sidonius Apollinaris in the fifth century. The Parisian MS. 7382 notes by a later hand the quotations from Vitruvius by these three writers. The scholiast on *h*, perhaps Fra Giocondo, quotes references to Pliny in which Vitruvius seems to furnish the material.

More striking still is the influence of Vitruvius upon the architecture of the Roman colonies which were founded in the early Empire. His circle of the winds was marked at many colonies in Africa, especially at Dougga, where the neighbouring Capitol¹ is said to follow the proportions of Vitruvius, probably in the second century A.D.

The eclipse of Rome by Theodoric and Justinian in the sixth century replaced Vitruvius by the designs of the Byzantine artists.² His work, however, was probably represented in the manuscripts of Cassiodorus at Squillace and of the Benedictines at Monte Cassino. He took a new life when Rome recovered under the Papacy. Along with the Latin Vulgate, Vitruvius probably was taken by Ceolfrid to the scriptorium at Jarrow, where Italian scribes wrote the Codex Amiatinus and—there is reason to think—the oldest extant MS., the Harleian, of Vitruvius. The circumstance that strictly speaking there was no such thing as Saxon architecture, implied that the “Roman style,” as it was called, was imitated. This did not necessarily involve the use of the orders, as may be seen by the epitome of

¹ See Frontispiece.

² There is a reference to Vitruvius, Book VIII. iii., in Tzetzes' commentary on Lycophron, *Alexandra*, 1024. He seems to have read *Victrivius*.

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Faventinus dating from the fourth century. What was followed was the use of building materials in the Roman manner. The Christian architects seized rather upon the basilica of Vitruvius than his pagan temple, a process which had already begun in Africa, where the basilicas of Timgad still retain the columnar style of the temple.

Benedictine missionaries carried religion and architecture of the Roman form from England to Charlemagne. That Germany owed Vitruvius to England appears from the fact that all the extant MSS. go back to *H*. At this point we take up the history of the MSS.

THE HISTORY OF THE MANUSCRIPTS OF VITRUVIUS

The origin and date of the oldest MS. *H*¹ have been variously assigned. Rose in his preface roundly states that it was written in Germany in the time of Charlemagne.² But a reconsideration of the origin of *H* has been rendered necessary by the discovery that the Codex Amiatinus was written not, as Tischendorf supposed,³ in Italy about A.D. 541, but in England at Jarrow (or Wearmouth), to which Ceolfrid brought manuscripts from Italy. Theodore, Archbishop of Canterbury, also, seems to have been the means by which an Italian manuscript of the Latin Vulgate came to the north to furnish the original of the Lindisfarne Gospels, about A.D. 690. This was written by the Bishop of Lindisfarne himself, a Saxon under the influence of Irish scribes.

Now let us turn to *H*. It was not completed, for four pages were left blank, probably for some of the illustrations to which Vitruvius refers. In the

¹ B.M. Harl. 2767.

² Ed. pref. iv.

³ *N.T. Amiatinum*, pref. xi.

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Parisian manuscript 7227 the diagram of the winds has a page to itself at the end. *H* puts this diagram at the side of the text,¹ the only illustration of Vitruvius which *H* contains. On the last of the blank pages in the body of the manuscript, however, there is the sketch of a cross in the same style as those which precede each of the Lindisfarne Gospels.² This trace of the Celtic tradition helps to define the origin of *H* in Northumbria.

When we turn to the Codex Amiatinus, we find that the scribe has added *amen* to each of the four gospels at the end, but to the Acts of the Apostles he has affixed at the end *Deo gratias amen*. In the same way *H* adds to the first book of Vitruvius *dō gratias amen*, and a similar ending marks the tenth book. When the script of *H* is considered, there appears a close resemblance of the rubrication and the uncial letters to the style of the Amiatinus. In the letters D and M, however, there is an alternation between the capital and the uncial forms. The A sometimes lacks the cross stroke and resembles the Greek capital lambda. In fact, where *H* differs from the style of the Amiatinus, so far as the uncial writing is concerned, it suggests the lapidary style of Pope Damasus.

More will be said about the Latinity of *H* in the sequel. For the present it is enough for our purpose to note that it was written while Latin was still vigorous and living. When we turn to Einhard and Charlemagne, the purist is already at work removing idioms (sometimes classical and ancient) because of their apparent contradiction of the grammarians. The very excellence of Einhard's Latin is largely due to its artificial character. In a word, it

¹ Book I. vi. 12.

² B.M. *III. MSS.* iii. 1.

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is doubtful whether *H* could have been written after the establishment of the Caroline school. At the same time the remarkable care with which *H* was written encourages us to see in it a faithful transcript of the Italian original and a witness of great value, therefore, for the Latin of the early Empire.

What kind of transformation Vitruvius would probably have undergone is illustrated for us by the text of *G*, which Rose and Krohn consider to represent an independent tradition from the original. A reference to the critical notes will prove, I think, that *G* is merely a recension of *H* carried out in the presumed interests of Latin style, and varying from *H* only in detail, except in the beginning of the first book, where a misunderstanding of the text has led to a wrong punctuation and to the interpolation of an unnecessary phrase. Fra Giocondo went much further than *G* in his divergence from the manuscript tradition. He had this excuse, however, that he treated Vitruvius as an authority of more than antiquarian value.

We can arrange the extant manuscripts, therefore, as follows: first those which derive from *H*, and these are the greater number; second, those which derive from *G*, to which may be added not only the second Gudianus quoted by Rose, but three late manuscripts, one in Paris 7228, the Bodleian F.5.7, and one in the Vatican *Codd. Urbinates Latini* 293; thirdly, a very late Parisian manuscript which has the reading *architectura* for *architecti*, was probably written under the direction of Giocondo, who is otherwise the main authority for this reading.¹

The spelling of the author's name as Victruvius is found in a group of MSS. belonging to the first class,

¹ Book I. i. 1.

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and apparently written in St. Augustine's Abbey, Canterbury. At any rate the Cotton MS., if not written there, was a possession of the Library,¹ and the Laudian MS., now at St. John's College, Oxford, was written at the Abbey in 1316. The origin of the mis-spelling seems to have been due to the carelessness of the rubricator of *c*, who gives yet another spelling, *Victurii*, in Book IX. The same spelling is found in two Harleian MSS.: 3859 *h*, which has *Victruvius*,² and 2760, which has *Victimi* (?), perhaps from *Victurii*.

Later on, evidence will be produced to show that *h* was the Blandinian manuscript used by Fra Giocondo; in other words it belonged to the great Benedictine house of St. Peter at Ghent. It is more than a coincidence that *h* is thus associated with two MSS. in the sister house at Canterbury. Further, the spelling *Victruvius* is employed by Sulpitius in the *editio princeps*. He was probably influenced by the bad rubrication of the late Escorial manuscript, which seems to read *Victini*, a manuscript which there is good reason to think Sulpitius used. Last of all there is the addition by a later hand of *Victruvius* on the page facing the illuminated beginning of Paris 7228.

But the three oldest MSS. which have this title are characterised by an important reading which has been overlooked by all those who have collated *H* hitherto, Book VII. pref. 11: *de incerta re incertae imagines*. *c* has *dein certarem*, *h* and the Laudian MS. *de incerta re incertae*. When we examine *H* we find the apparent reading *de incerta re*, but the *e* in *re* has a flourish not unlike the symbol for *m* and

¹ James, *Ancient Libraries of Canterbury and Dover*, p. 519.

² Cf. *supra* p. 11, n³.

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justifying *c's dein certarem*. There is a case, therefore, for the reading *incertae imagines*, if we suppose that the scribe of *H* found *in* before him and read it as *m*. More than this, if we follow Vitruvius' train of thought, the *incerta res* will carry with it *incertae imagines*. Hence Mr. Krohn quite consistently changes *incerta* before *res* to *certa*, on the accepted assumption that *certae imagines* is the accurate reading. But the uncertain things and the uncertain images harmonise with the teaching of Democritus, who, like St. Augustine, found certainty in reason. For Democritus, "reality consists in space and the geometrical forms of matter,"¹ i.e. in the formal or rational factor of experience! Hence Vitruvius correctly states the principles of Democritus in the passage that we are considering. That these principles coincide to some extent with St. Augustine's² would commend them to an Augustinian, especially at Canterbury, where the Abbey library contained the *Hortensius*³ of Cicero: under this title we are to understand the *Academica* in which Cicero expounds the scepticism of Carneades about sense-experience.⁴ But in Augustine's own works this attitude is widely enough represented. We might, therefore, almost regard this group of the Vitruvius MSS. as Augustinian. To this group may perhaps be added the late Escorial MS. on the ground of the mis-spelling of the title *Victini*, which resembles that of the Harleian 2760, *Victimini*. The latter, further, is followed by the Escorial MS. in the designs of the initial letters. In these there is a touch of the Celtic manner which seems to have

¹ Windelband, *Iwan Müller*, V. i. 211.

² Martin, *Saint Augustin*, p. 277.

³ James, *op. cit.*, p. 305.

⁴ Reid, *Academica*, p. 31 n.

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been handed down through the centuries from the scribes of Northumbria.

THE EARLIEST PRINTED EDITIONS OF VITRUVIUS, AND THEIR MS. AUTHORITY

After being engaged for a considerable time in tracing the history of the manuscripts of Vitruvius I met with a striking coincidence.¹ Three years ago I visited the Escorial Library in order to examine two manuscripts there. Of these, one was obviously late, probably of the fifteenth century. It was unusually rich, however, in marginal notes; by the courtesy of the Director I was enabled to have a photographic reproduction made, and with this before me I found two notes, in a much later hand, of considerable interest. The first compared an abbreviation with a similar abbreviation in *Blandiniano* (Book VII., pref.). The second took note of the well-known dislocation of a folio of the archetype later on in the same book, and again referred to a Blandinian manuscript.

Now Fra Giocondo was the first editor of Vitruvius to remedy this dislocation in his text. His name, therefore, at once suggested itself as the writer of these two notes. It is possible, of course, that Fra Giocondo—assuming for a moment him to be the writer—had borrowed the manuscript from the famous Benedictine house of St. Peter at Ghent. But there is an alternative possibility. He might have read it on the spot. When Fra Giocondo was

¹ The personal note in the following section may perhaps be excused in view of the hypothetical character of the material. By the courtesy of the editor, the suggestions contained appeared in the *Times Literary Supplement*, March 21, 1929.

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preparing his edition of Caesar, he "sought out many examples throughout Gaul; in which province (because many had always been brought from Italy and were less exposed to loot and war) more accurate manuscripts of every kind are found."¹ He might, therefore, conceivably have visited the neighbouring and famous library of St. Peter. Cruquius, speaking of the Blandinian manuscripts of Horace, says that they were brought from Rome. The manuscripts of Horace disappeared, it would seem, in the iconoclastic riots at Ghent and accompanying fire of 1566. Is it possible that the Blandinian Vitruvius escaped? At any rate it is recorded that as late as 1809 manuscripts from the monastery were seized in Holland.

But there is another line of approach. This same Escorial manuscript which furnished the two scholia turns out to have the closest affinity to the first printed edition of Vitruvius, that of Sulpitius. Sulpitius collated many manuscripts. But he used especially one written for him by a friend Delius; which I am tempted to identify with the Escorial manuscript. *Satis accurate perscripto* implies only a moderate praise in Sulpitius' account of it. The Escorial MS. is rather poorly written. The abbreviations correspond with those used in Sulpitius' text, and many characteristic renderings are found in the MS. which are repeated in the printed edition. The MS. came from the library of Olivares, the famous Spanish statesman, who was born at Rome, where his father was Ambassador to Sixtus V. The Italian origin of the Escorial manuscript would thus be explained. The history of the manuscript would begin with Sulpitius, go on to Giocondo, and then arrive at Olivares after an interval.

¹ *Caesar*, pref., Paris, 1544.

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The edition of Sulpitius offers a further clue. As we have seen, he prints the name of the Latin author as *Victruvius*; we may infer that one of his manuscripts derived from Canterbury.

Let us now examine the Harleian *Vitruvius h*. Again, the margin furnishes two illuminating notes. The same (?) handwriting as that of the Escorial scholiast calls attention in two places (Book VII., pref. and c. i.) to the abbreviation already noted above, *uti s. s. e.* (for *uti supra scriptum est*). This abbreviation was wrongly transcribed in the Escorial manuscript, and misunderstood by Sulpitius. Giocondo, on our supposition, notes the correct text of the Harleian, which duly appears in full in his printed edition, *uti supra scriptum est*. It seems probable then that Giocondo used these two manuscripts in constituting his text. But it is doubtful whether he read the Harleian at Ghent or in Italy. It is also doubtful whether Sulpitius got his reading *Victruvius* from the Harleian or from another descendant of the Cottonian *Vitruvius*.

It may seem a slight foundation for so large a superstructure of conjecture. But photography has made it possible to put side by side the handwriting on the margins of the two manuscripts. The comparison is convincing.

The inquiry as to the movements of the Vitruvian manuscript is of the first importance for the history of architecture. The case before us exhibits Fra Giocondo at work on the text received by the architects of the Renaissance. It is noteworthy when we see him recording for the first time the dislocation of a folio in the archetype. It is not less memorable when we find him altering the first word that follows upon the preface to the first book; there

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can be seen in the Escorial manuscript (I think in Fra Giocondo's writing) the substitution of *architectura* for *architecti*, to be repeated in Barbaro's translation and Philander's edition. This was but the first of many arbitrary changes.

Yet there was one quality in Fra Giocondo's work which compensates for his somewhat cavalier scholarship. He had in view the practical application of the rules of Vitruvius, an aim attempted by Wotton in his *Elements of Architecture*. This attitude to Vitruvius explains the history of the text. The admirable work of another (the present) Provost of Eton, *The Ancient Libraries of Canterbury and Dover*, enables us to see St. Augustine's Abbey library at Canterbury as the centre from which manuscripts were diffused not only by "conveyance" but by lawful copying. The Harleian Vitruvius¹ seems to be a case in point. Whether this is the Blandinian codex or not, the Blandinian Abbey of St. Peter at Ghent held enormous possessions in England from the tenth century onwards, and there is no improbability in the suggestion that the scribes of St. Augustine's, Canterbury, furnished books for the library across the Channel.

The latest Harleian MS. of Vitruvius² has the characteristic mis-spelling of the author's name, in this case *Victimi*, which leads us to think of the Augustinian scribes. And when we find at the beginning of the MS. the inscription *iste liber est monasterii* (name erased) we have grounds for thinking that it was part of the loot of the Blandinian monastery of St. Peter.

¹ B.M. 3859.

² B.M. 2760.

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THE SCHOLIA IN THE MSS. OF VITRUVIUS

We must distinguish between that part of the MS. which is due to the author and the various additions which are found from other sources. Vitruvius never mentions his own name. In this respect he anticipates the writers of the four gospels. His work probably first took shape in ten papyrus rolls kept together in a canister with a slip of parchment attached (*titulus* or title) giving the name of the author and the work. Hence in many cases where the author's name is not mentioned in the text and the *tituli* have disappeared, the author's name disappears too. In Vitruvius' case, the fact that he is mentioned by Pliny the Elder secured to some extent the survival of his name.

The divisions of the work into books, and of the separate books into preface and the main part of each book, are the author's own. But he is not responsible for the divisions into chapters, which are due to Fra Giocondo, and the further divisions into paragraphs, which are due to Schneider. The titles of the chapters of the first book alone are given in *H*, but these are neither convenient nor accurate. I have given them English renderings, however, but have excluded them from the Latin text.

Such additions to the text are found in most MSS., and often furnish, as in this case, valuable clues to the history of the MSS. Round the works of authors more frequently read there have gathered the commentaries of scholars, as in the case of Virgil. Vitruvius, however, furnishes, so far as I know, but two MSS. with scholia, the later Escorial and the Harleian *h*. In the belief that by them valuable light would be thrown on the history of the text,

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I procured photographic reproductions. To the Escorial MS. are due the references to the Blandinian MS.; the rest of the scholia are in the same hand as the text and seem to be a repetition, on the side, of words from the text with a view to the preparation of an index.

The scholia of *h* are mainly from two hands. The bolder occasionally notes the topics treated in the text. The other, which I have ventured to attribute to Fra Giocondo, annotates the text as if for publication. Chapters and paragraphs are marked much as in his edition. Various readings which correspond with his text are introduced as corrections. σκιογραφία, I. ii. 2; *fontiū nymphis* I. ii. 5; *s* = *semis* written in full V. i. 6; *eduxerit* is found in *e*₂ Sulp. Joc., II. pref. 3, and so on. Reference has already been made to the two notes on *uti supra scriptum est* repeated in *e*₂.

Vasari in his *Lives* says little of Fra Giocondo as an architect, but much of his engineering and scientific attainments. Accordingly, we find two notes which could scarcely have been written by anyone else than Fra Giocondo. Vitruvius, I. vi. 2, describes the heating of water in a bronze sphere with a small aperture at the top, and the consequent rush of air. A note states: *vidi hoc Venetiis saepe fieri*, "I have often seen this done at Venice." Vitruvius, II. ix. 11, remarks that Ravenna was built on piles; *idem nunc Venetiis*, says a note (Cooper's *Thesaurus* correctly gives the Latin name of Venice as *Venetiae*¹). The principle of the steam-engine was understood, but it had to wait for improvements in metallurgy to be turned to account three centuries

¹ Fra Giocondo uses this spelling in the preface to his *Caesar*.

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later. The other note suits the mind of the engineer, who compares the situation of Ravenna with that of Venice, where he had been employed.

I can imagine an impatient critic protesting against these references to the practical use of Vitruvius. Fra Giocondo was one of those universal geniuses whom Pythius had in view,¹ and whose existence Vitruvius denied (*ib.*). He vindicated architectural genius against the commonplace, of which Vitruvius was the prophet.

THE ILLUSTRATIONS OF THE MSS.

Vitruvius seems to have given illustrations at the end of his several books. Of these none have come down except perhaps the diagram of the winds in Book I, and this is found in *H* not at the end of the book, but in the margin opposite the text to which it refers.

The most important MS. in this respect of those which I have seen is *p*₁. There is a dislocation of leaves due to the binder. After 34 the order should be 36, 35, 38, 37. On 35 obverse there is inserted, in the right-hand margin, a square one inch across with a diagonal from left to right. This is indented a quarter of an inch into the text, and faces the reference to Pythagoras and his famous theorem. At the foot there is a drawing of a water-screw, *turris cochlearis*, which is represented as vertical, but is accompanied by the instruction that it is to be inclined from the perpendicular.

The beautiful illumination of the first page of Par. 7228 contains three portraits presumably of Vitruvius, Octavia and Augustus. In like fashion

¹ Book I. i. 11.

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the Eton MS. presents Vitruvius. But these pictures are creatures of the imagination.

The text of Vitruvius would admit of very many illustrations, more indeed than any edition could supply. The reader may be referred to Smith's *Dictionary of Antiquities*. Short of this, the illustrations furnished will explain some of the most characteristic topics.

THE LANGUAGE OF VITRUVIUS

The text of the present edition represents more closely than its predecessors that of *H*. In doing so it disregards many of the corrections and emendations of Rose and Krohn. From the sequel it will appear that the text of *H* has been altered by the editors in many places where it faithfully preserves the ancient, and in some cases the standard, idiom.

For the language of *H* is not so far, as it might sound at first, even from the classical Latin of 30 B.C.; it is still nearer the vernacular, the spoken Latin of the workshop and the street. Of this unliterary Latin few traces can be expected in literature: yet the casual inscription and the casual scrawl upon the stucco of Pompeii give us hints towards the understanding of Vitruvius. There is help from elsewhere. The Old Latin versions of the Gospels, which were largely used by Jerome in forming the Latin Vulgate, go back probably to the beginning of the second century. Cardinal Wiseman drew attention¹ to the importance of the African versions as containing the oldest Latin text of the New Testament, the reason being that Greek was the language of the Roman Church at the time of Vitruvius and probably as late as A.D. 200. I am

¹ *Essays*, I. 40 ff.

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indebted to Wiseman's essay for some of the parallels to the language of Vitruvius. Other parallels are drawn from the Old Latin MS. *k*,¹ which is almost identical with the biblical quotations of Cyprian. The later Old Latin MSS. exhibit a recension which gradually diverges towards a more classical form in a manner which is illustrated by the history of the text of Vitruvius. And, generally, the Latin-speaking Africans furnish us with some of the earliest evidence of the influence of Vitruvius.

Mr. Krohn has improved on the text of Rose in many places by returning to *H*. From the following examination of readings it will be seen that we may go much further.

Punctuation often enables us to recover the original. The reading of *c*, *dein certarem*, VII., pref. 11, gives us *de incerta re* and, in *m certae imagines*, the *incertae imagines* which the argument demands. In another case, by retaining the punctuation of *H* we have the striking and not impossible statement *si credam rationem*, which was altered by later scribes to avoid the grammatical solecism of an accusative after *credo*, I. i. 8.²

Punctuation wrongly used gave a mistaken turn to the definition of the architect's calling with which the book begins after the first preface. By postponing the stop to *opera*, the scribe of *G* seems to have found necessary the interpolation *cuius iudicio probantur omnia*. But if, with the Vatican MS. *v*₁ we punctuate after *perficiuntur*, *opera* recovers the meaning "personal service" or better "work," through which it passed into the French *œuvre*,

¹ *Old Latin Biblical Texts*, II., Oxford, 1886.

² Tacitus uses an accusative after *fungor*, *Ann.*, III. ii. 1, IV. xxxviii. 1.

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further giving rise to *operarius* in Latin and thereby to *ouvrier* in French. The *ea* which follows is equivalent, as so often in Vitruvius, to the article. *Opera ea* = *l'œuvre*. It is then analysed into *fabrica* "handiwork," and *ratiocinatio* "brainwork."

By inserting a comma *uti cuneus*, I. v. 5 becomes an illustration. I should like to retain *ferroque* II. viii. 12, with a comma to separate it from *more*. To the Ciceronian *e duro ferroque* may seem harsh and forced; but is it beyond the range of Sallust? A comma after *parvas partes* will imply that a part of the verb *esse* is supplied with *distributa*. Hence it is unnecessary with Mr. Krohn to add *non* before *poterit* I. v. 7.

As examples of archaic spellings we find *mare* abl. I. iii. 11 with Lucretius; *ferundo* I. i. 5; *alii* gen. II. ix. 5; *secuntur* from *sequor*.

I have restored some good spellings from *H*: *circuitionibus* I. i. 7; *turrim* and *turrem* are found side by side, I. vi. 4, reminding us that the rules for spelling were still flexible. (The great inscription of Augustus in Ancyra has *conlegio* and *collega* in the same sentence, IV. 22.) *Mercuri* gen. sing. should not have been altered by Rose and Krohn, II. viii. 11; the reading of *H* in V. x. 5 seems to be *clupei²m*, the correction of *o* by the first hand to *u* being made with a letter like *y* (Augustus' inscription having *clupei* VI. 34); *praegnates* II. ix. 1 is found in Plautus and frequently in Pliny, *N.H.*; *reciperantur* should stand, II. ix. 2.

H's language is tinged with old technical spellings natural in builders' specifications. *doleis* V. v. 1 is supported by Varro, *R.R.* I. 61. Under the same head come lengthy compounds like *exsuperationibus* I. iv. 8, and *inambulationes* I. iii. 1. The last example

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is instructive. Compounds with *in* are frequent and have sometimes been altered by Krohn unnecessarily, as here, on the ground that the mediaeval scribes often added *in*. The repetition of synonyms is frequent; it is dangerous to remove them as glosses. *gnomon indagator umbrae* I. vi. 6. Another characteristic of specifications is the use of singular for plural: *in tertio et quarto volumine* I. vii. 2; this should have prevented the alteration to the plural of *erit littera e et f*, I. vi. 12. The not infrequent omission of the verb *esse* also characterises early African Latin, as in the N.T. MS. *k*.

The description of the basilica at Fano, V. i. 6, has puzzled some critics. It is obviously taken from something like a specification. The argument from language against its ascription to Vitruvius is unconvincing to an architect who, like the present writer, has written specifications and employed the traditional idiom with its archaic and technical terms. I will allow myself but one reference. Mr. Krohn, pref. v, cites *negotiantes* (for *negotiatores*) as not Vitruvian. The use of the participle as a noun of agency is characteristic of African Latin; *discentes* for *discipuli* in the N.T. MS. *k*. It also occurs in Sallust, Caesar, Cicero, Livy. The reader of the following pages, therefore, may find in the basilica the precedent followed to some extent throughout the Middle Ages, and set by Vitruvius himself.¹

¹ Scott, *History of English Church Architecture*, p. 4 ff.

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THE following MSS. have been used in constituting the text and in determining its history. Rose and Krohn agree in referring all the extant MSS. to *H* and *G* as representing an unknown original, and have intentionally neglected the later MSS., which they refer to one or other of these sources. I have carried their process one step further, by showing, as I think, that *G* is a recension of *H*. For *E*, *G* and *S*, I have availed myself of the collations of Rose and Krohn. The remaining fourteen MSS. I have collated myself, *H*, *h* and *e*₂ minutely. They confirm the derivation of the later MSS. from *H* and *G*.

H. London, British Museum, Harl. 2767 ¹ (8th cent.).

S. Selestad. Bibl. 1153 (10th cent.).

E. Wolfenbüttel, Bibl. 132 (10th cent.).

G. Wolfenbüttel, Bibl. 69 (11th cent.), with excerpts from I-III, V-X.

The following MSS. are derived from *H*: they are sometimes denoted generally as *rec.* (*recentiores*).

c. London, B.M., Cotton, Cleop. (10th cent.).

The rubricator gives the author's name as

¹ *H* inserts some chapter headings in the first book, probably later than the text itself. These headings have been inserted in the translation.

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- i.* Oxford, St. John's Coll. 66 *B* (1316 A.D.).
- e₂.* Escorial, II. 5 (15th cent.).
- h₂.* London, B.M., Harl. 2760 (15th cent.).
- p₁.* Paris, Bibl. Nat. 7227 (11th cent.).
- e₁.* Escorial, III. 19 (11th or 12th cent.).
- et.* Eton College, MSS. 137 (15th cent.).
- v₁.* Rome, Vatican Codd. Urbin. Lat. III. 1360 (15th cent.).
- p₃.* Paris, Bibl. Nat. 7382 (15th cent.).

The following MSS. are derived through *E* and *G* :

- p₂.* Paris, Bibl. Nat. 7228 (14th cent.).
- o₂.* Oxford, Bodleian, F. v. 7 (15th cent.).
- v₂.* Rome, Vatican Codd. Urbin. Lat. I. 293 (15th cent.).

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- Sulp. : ed. princeps. by Sulpitius, Rome, c. 1486, fol.
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- Perr. : Perrault, Paris, 1673, fol.
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- Kr. : Krohn, Leipzig, 1912, 8vo.

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Morgan, Harvard, 1914, 8vo., illust.

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fol.

Vignola : *Regola della cinque ordini d'Architettura*.

Of this there are several French translations.

Palladio : *Libri IV dell' Architettura*, Venice, 1570,
fol.

Goujon : Essay contained in Martin's translation
of Vitruvius, Paris, 1547.

De Brosse : *Reigle Générale*, Paris, 1619, fol.

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await publication.

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the rules of Vitruvius to their buildings, and are
important for the understanding of Roman archi-
tectural practice.

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Polenus : *Exercitationes Vitruvianae*, Patavii, 1739.

Fea : Winkelmann, tr. Rome, 1783-4. Three
vols., 4to. (*Sulle rovine di Roma*.)

Donaldson : Trans. *R.I.B.A.* Vol. I, 1834. (On
MSS. of Vitruvius.)

The Harleian MSS. including *H* appear in this
list, as also the Wolfenbüttel MSS. including *G*.
But Vitruvian studies were almost fruitless for a

¹ Much that has been written on Vitruvius may safely be
neglected.

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generation until the edition of Rose, 1867. They were overshadowed on the one hand by the renaissance of Greek architecture beginning with Stuart and Revett's *Antiquities of Athens*, 1762-1816, and on the other by the renaissance of Gothic architecture beginning with Horace Walpole. The Greek revival has thrown much light on the authorities followed by Vitruvius and vindicated his accuracy.¹ His influence upon Einhard largely determined the architectural school of Charlemagne and thereby the development of Gothic architecture.

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by the two following.)

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hand; he is followed by Krohn.)

¹ Vitruvius' description of the Temple of Zeus Olympios at Athens as octastyle has been proved correct in recent excavations.

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VITRUVIUS
ON ARCHITECTURE
BOOKS I—V

VITRUVII
DE ARCHITECTURA
LIBER PRIMUS

- 1 Cum divina tua mens et numen, imperator Caesar, imperio potiretur orbis terrarum invictaque virtute cunctis hostibus stratis triumpho victoriaque tua cives gloriarentur et gentes omnes subactae tuum spectarent nutum populusque Romanus et senatus liberatus timore amplissimis tuis cogitationibus consiliisque gubernaretur, non audebam, tantis occupationibus, de architectura scripta et magnis cogitationibus explicata edere, metuens, ne non apto tempore interpellans subirem tui animi offensionem.
- 2 Cum vero adtenderem te non solum de vita communi omnium curam publicaeque rei constitutionem habere sed etiam de opportunitate publicorum aedificiorum, ut civitas per te non solum provinciis esset aucta, verum etiam ut maiestas imperii publicorum aedificiorum egregias haberet auctoritates, non putavi praetermittendum, quin primo quoque

¹ Augustus' admiral defeated Antony and Cleopatra at Actium 31 B.C.

² The young Octavian had shared in the proscription of 42 B.C., but his triumph of 31, was followed by an amnesty.

VITRUVIUS

ON ARCHITECTURE

BOOK I

PREFACE

1. WHEN your Highness's divine mind and power, O Caesar, gained the empire of the world,¹ Rome gloried in your triumph and victory. For all her enemies were crushed by your invincible courage and all mankind obeyed your bidding; the Roman people and senate were not only freed from fear² but followed your guidance, inspired as it was by a generous imagination. Amid such affairs I shrank from publishing my writings on architecture in which I displayed designs made to a large scale, for I feared lest by interrupting at an inconvenient time, I should be found a hindrance to your thoughts.

2. But I observed that you cared not only about the common life of all men, and the constitution of the state, but also about the provision³ of suitable public buildings; so that the state was not only made greater through you by its new provinces, but the majesty of the empire also was expressed through the eminent dignity of its public buildings. Hence I conceived that the opportunity

³ Augustus boasted that he found a Rome of brick, and left one of marble.

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tempore de his rebus ea tibi ederem, ideo quod primum parenti tuo de eo fueram notus et eius virtutis studiosus. Cum autem concilium caelestium in sedibus immortalitatis eum dedicavisset et imperium parentis in tuam potestatem transtulisset, idem studium meum in eius memoria permanens in te contulit favorem.

Itaque cum M. Aurelio et P. Minidio et Cn. Cornelio ad apparationem balistarum et scorpionum reliquorumque tormentorum refectionem fui praesto et cum eis commoda accepi, quae, cum primo mihi tribuisti recognitionem, per sororis commendationem servasti.

- 3 Cum ergo eo beneficio essem obligatus, ut ad exitum vitae non haberem inopiae timorem, haec tibi scribere coepi, quod animadverti multa te aedificavisse et nunc aedificare, reliquo quoque tempore et publicorum et privatorum aedificiorum, pro amplitudine rerum gestarum ut posteris memoriae traderentur, curam habiturum. Conscripsi praescriptiones terminatas, ut eas adtendens et ante facta et futura qualia sint opera, per te posses nota habere. Namque his voluminibus aperui omnes disciplinae rationes.

¹ Augustus was the great nephew of Julius Caesar, and was adopted by his will. Augustus' mother Atia belonged to Aricia, near Nemi. The name occurs on tiles found at Nemi. Atia's mother Julia was the sister of Caesar (whose bust was found at Nemi and is now in the Castle Museum, Nottingham).

² Artillery described in Book X.

BOOK I. PREFACE

should be taken at once of bringing before you my proposals about these things: the more so, because I had been first known to your father¹ herein, whose virtues I revered. When, however, the Council of Heaven gave him an abode in the mansion of the immortals and placed in your power your father's empire, that same zeal of mine which had remained faithful to his memory found favour also with you.

Therefore, along with M. Aurelius and P. Minidius and Cn. Cornelius, I was put in charge of the construction and repair of *balistae*² and *scorpiones*² and other engines of war, and, along with my colleagues, received advancement. After first granting me this surveyorship,³ you continued it by the recommendation of your sister.

3. Since, then, I was indebted to you for such benefits that to the end of life I had no fear of poverty, I set about the composition of this work for you. For I perceived that you have built, and are now building, on a large scale. Furthermore, with respect to the future, you have such regard to public and private buildings, that they will correspond to the grandeur of our history, and will be a memorial to future ages. I have furnished a detailed treatise so that, by reference to it, you might inform yourself about the works already complete or about to be entered upon. In the following books I have expounded a complete system of architecture.

³ It was in a similar capacity that Vitruvius controlled the plumbing at Rome. Frontin. *Aquaed.* 23.

VITRUVIUS

I

- 1 ARCHITECTI est scientia pluribus disciplinis et variis eruditionibus ornata, [cuius iudicio probantur omnia]¹ quae ab ceteris artibus perficiuntur. Opera ea nascitur et fabrica et ratiocinatione. Fabrica est continuata ac trita usus meditatio, quae manibus perficitur e materia cuiuscumque generis opus est ad propositum deformationis. Ratiocinatio autem est, quae res fabricatas sollertiae ac rationis proportionem demonstrare atque explicare potest.
- 2 Itaque architecti, qui sine litteris contenderant, ut manibus essent exercitati, non potuerunt efficere, ut haberent pro laboribus auctoritatem; qui autem ratiocinationibus et litteris solis confisi fuerunt, umbram non rem persecuti videntur. At qui utrumque perdidicerunt, uti omnibus armis ornati citius cum auctoritate, quod fuit propositum, sunt adsecuti.
- 3 Cum in omnibus enim rebus, tum maxime etiam in architectura haec duo insunt, quod significatur et quod significat. Significatur proposita res, de qua dicitur; hanc autem significat demonstratio rationibus doctrinarum explicata. Quare videtur utraque parte exercitatus esse debere, qui se architectum profiteatur. Itaque eum etiam ingeniosum oportet esse et ad disciplinam docilem.

¹ cuius iudicio probantur omnia *G S: om. H.*

¹ The misunderstanding of *opera* as "works" instead of "personal service" led to the erroneous punctuation which puts the period after instead of before *opera*. The reading and punctuation of the text are found curiously enough in the

BOOK I. c. I.

CHAPTER I

ON THE TRAINING OF ARCHITECTS

1. THE science of the architect depends upon many disciplines and various apprenticeships which are carried out in other arts. His personal service¹ consists in craftsmanship and technology. Craftsmanship is continued and familiar practice, which is carried out by the hands² in such material as is necessary for the purpose of a design. Technology sets forth and explains things wrought in accordance with technical skill and method.

2. So architects who without culture aim at manual skill cannot gain a prestige corresponding to their labours, while those who trust to theory and literature obviously follow a shadow and not reality. But those who have mastered both, like men equipped in full armour, soon acquire influence and attain their purpose.

3. Both in general and especially in architecture are these two things found; that which signifies and that which is signified. That which is signified is the thing proposed about which we speak; that which signifies is the demonstration unfolded in systems of precepts. Wherefore a man who is to follow the architectural profession manifestly needs to have experience of both kinds. He must have both a natural gift³ and also readiness to learn.

very late Vatican MS. Codd. Urbin. 1360 except that *opera eius*, replaces *opera ea*.

² The word "hand" scarcely occurs in the index to Plato, and is glorified by Aristotle who defines it as *organon organon* "the tool which makes tools."

³ Vitruvius recognises the genius of the craftsman.

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Neque enim ingenium sine disciplina aut disciplina¹ sine ingenio perfectum artificem potest efficere. Et ut litteratus sit, peritus graphidos, eruditus geometria, historias complures noverit, philosophos diligenter audierit, musicam scierit, medicinae non sit ignarus, responsa iurisconsultorum noverit, astrologiam caelique rationes cognitae habeat.

- 4 Quae cur ita sint, haec sunt causae. Litteras architectum scire oportet, uti commentariis memoriam firmiorem efficere possit. Deinde graphidis scientiam habere, quo facilius exemplaribus pictis quam velit operis speciem deformare valeat. Geometria autem plura praesidia praestat architecturae; et primum ex euthygrammis circini traditum, e quo maxime facilius aedificiorum in areis expediuntur descriptiones normarumque et librationum et linearum directiones. Item per optice in aedificiis ab certis regionibus caeli lumina recte ducuntur. Per arithmetice vero sumptus aedificiorum consummantur, mensurarum rationes explicantur, difficilesque symmetriarum quaestiones geometricis rationibus et methodis inveniuntur.
- 5 Historias autem plures novisse oportet, quod multa ornamenta saepe in operibus architecti designant, de quibus argumentis rationem, cur fecerint, quaerentibus reddere debent. Quemadmodum si quis statuas marmoreas muliebres stolatas, quae cariatides dicuntur, pro columnis in opere statuerit et insuper mutulos et coronas conlocaverit, percontanti

¹ aut sine ingenio disciplina *G*.

¹ Note the reference to water-colour drawings.

BOOK I. c. I.

(For neither talent without instruction nor instruction without talent can produce the perfect craftsman.) He should be a man of letters, a skilful draughtsman, a mathematician, familiar with historical studies, a diligent student of philosophy, acquainted with music; not ignorant of medicine, learned in the responses of jurisconsults, familiar with astronomy and astronomical calculations.

4. The reasons why this should be so are these. An architect must be a man of letters that he may keep a record of useful precedents. By his skill in draughtsmanship he will find it easy by coloured¹ drawings to represent the effect desired. Mathematics again furnishes many resources to architecture. It teaches the use of rule and compass and thus facilitates the laying out of buildings on their sites by the use of set-squares, levels and alignments. By optics,² in buildings, lighting is duly drawn from certain aspects of the sky. By arithmetic, the cost of building is summed up; the methods of mensuration are indicated; while the difficult problems of symmetry are solved by geometrical rules and methods. 5. Architects ought to be familiar with history because in their works they often design many ornaments about which they ought to render an account to inquirers. For example, if anyone in his work sets up, instead of columns, marble statues of long-robed women which are called caryatids,³ and places mutules and cornices above them, he will thus

¹ The science of optics includes perspective to which many references will be found.

² The caryatides of the Erechtheum at Athens were first known as *korai* or "maidens."

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bus ita reddet rationem. Caria, civitas Peloponnensis,¹ cum Persis hostibus contra Graeciam consensit. Postea Graeci per victoriam gloriose bello liberati communi consilio Cariatibus bellum indixerunt. Itaque oppido capto, viris interfectis, civitate declarata² matronas eorum in servitutem abduxerunt, nec sunt passi stolas neque ornatus matronales deponere, uti non una triumpho ducerentur, sed aeterno, servitutis exemplo gravi contumelia pressae poenas pendere viderentur pro civitate. Ideo qui tunc architecti fuerunt aedificiis publicis designaverunt earum imagines oneri ferundo conlocatas, ut etiam posteris nota poena peccati Cariatium memoriae traderetur. Non minus Lacones, Pausania Agesilae³ filio duce, Plataeeo⁴ proelio pauca manu infinitum numerum exercitus Persarum cum superavissent, acto cum gloria triumpho spoliis et praedae, porticum Persicam ex manubiis, laudis et virtutis civium indicem, victoriae posteris pro trophaeo constituerunt. Ibique captivorum simulacra barbarico vestis ornatu, superbia meritis contumeliis punita, sustinentia tectum conlocaverunt, uti et hostes horrescerent timore eorum fortitudinis effectus, et cives id exemplum virtutis aspicientes gloria erecti ad defendendam libertatem essent parati.

¹ peloponnessis *H.*

² de forte sensu *privativo.*

³ Agesilae *Sch.*

⁴ Plataeeo *Joc:* pitalco *H.*

¹ The legend reported here may perhaps be explained by the traditional enmity of the Carians in Asia Minor, II. viii. 12; IV. i. 5. The spelling of *H. Caria*, throws some doubt upon the usual reference to the Arcadian Caryae. The Cnidians used caryatid figures (of a style similar to the early draped female statues of the Acropolis) in their treasury at Delphi. These may have originated the legend.

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render an account to inquirers. Caria,¹ a Peloponnesian state, conspired with the Persian enemy against Greece. Afterwards the Greeks, gloriously freed from war by their victory, with common purpose went on to declare war on the inhabitants of Caria. The town was captured; the men were killed; the state was humiliated. Their matrons were led away into slavery and were not allowed to lay aside their draperies and ornaments. In this way, and not at one time alone, were they led in triumph. Their slavery was an eternal warning. Insult crushed them. They seemed to pay a penalty for their fellow-citizens. And so the architects of that time designed for public buildings figures of matrons placed to carry burdens; in order that the punishment of the sin of the Cariatid women might be known to posterity and historically recorded. 6. Not less the Spartans under the command of Pausanias, son of Agesilas,² having conquered with a small force an infinitely large army of Persians, gloriously celebrated a triumph with spoils and plunder, and, from the booty, built the Persian Colonnade³ to signify the merit and courage of the citizens and to be a trophy of victory to their descendants. There they placed statues of their captives in barbaric dress—punishing their pride with deserved insults—to support the roof, that their enemies might quake, fearing the workings of such bravery, and their fellow-citizens looking upon a pattern of manhood might by such glory be roused and prepared for the defence of freedom. Therefrom many

¹ Herod iv. 81, says Cleombrotus.

² At Sparta, Paus. III. xi. 3.

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Itaque ex eo multi statuas Persicas sustinentes epistylia et ornamenta eorum conlocaverunt, et ita ex eo argumento varietates egregias auxerunt operibus. Item sunt aliae eiusdem generis historiae, quarum notitiam architectos tenere oporteat.

7 Philosophia vero perficit architectum animo magno et uti non sit adrogans, sed potius facilis, aequus et fidelis, sine avaritia, quod est maximum; nullum enim opus vere sine fide et castitate fieri potest; ne sit cupidus neque in muneribus accipiendis habeat animum occupatum, sed cum gravitate suam tueatur dignitatem bonam famam habendo; et haec enim philosophia praescribit. Praeterea de rerum natura, quae graece *physiologia* dicitur, philosophia explicat. Quam necesse est studiosius novisse, quod habet multas et varias naturales quaestiones. Ut etiam in aquarum ductionibus. Incursum enim et circuitibus et librata planitie expressionibus spiritus naturales aliter atque aliter fiunt, quorum offensionibus mederi nemo poterit, nisi qui ex philosophia principia rerum naturae noverit. Item qui Ctesibii¹ aut Archimedis et ceterorum, qui eiusdem generis praecepta conscripserunt, leget, sentire non poterit, nisi his rebus

8 a philosophis erit institutus. Musicen autem sciat oportet, uti canonicam rationem et mathematicam notam habeat, praeterea balistarum, catapultarum, scorpionum temperaturas possit recte facere. In

¹ Ctesibii *Joc.*

¹ Vitruvius was acquainted with Lucretius' poem "On the Nature of Things," IX. iii. 17.

² An engineer at Alexandria, c. 250 B.C.

³ An engineer at Syracuse, c. 250 B.C.

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have set up Persian statues to support architraves and their ornaments. This motive has supplied for their works some striking variations. There are also other narratives of the same kind with which architects should possess acquaintance. 7. Philosophy, however, makes the architect high-minded, so that he should not be arrogant but rather urbane, fair-minded, loyal, and what is most important, without avarice; for no work can be truly done without good faith and clean hands. Let him not be greedy nor have his mind busied with acquiring gifts; but let him with seriousness guard his dignity by keeping a good name. And such are the injunctions of philosophy. Philosophy, moreover, explains the "nature of things"¹ (and this in Greek is *physiologia*), a subject which it is necessary to have studied carefully because it presents many different natural problems, as, for example, in the case of water-supply. For in the case of water-courses, where there are channels or bends or where water is forced along on a levelled plane, natural air-pockets are produced in different ways, and the difficulties which they cause cannot be remedied by anyone unless he has learnt from philosophy the principles of nature. So also the man who reads the works of Ctesibius² or Archimedes³ and of others who have written manuals of the same kind will not be able to perceive their meaning, unless he has been instructed herein by philosophers. 8. A man must know music that he may have acquired the *acoustic*⁴ and mathematical relations and be able to carry out rightly the adjustments of *balistae*, *catapultae* and *scorpiones*. For in the cross-

⁴ *Gell.* XVI. xviii. 5.

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capitulis enim dextra ac sinistra sunt foramina hemi-
toniorum, per quae tenduntur suculis¹ et vectibus e
nervo torti funes, qui non praecluduntur nec prae-
ligantur, nisi sonitus ad artificis aures certos et
aequales fecerunt. Bracchia enim, quae in eas
tentiones includuntur, cum extenduntur, aequaliter
et pariter utraque² plagam mittere debent; quodsi
non homotona³ fuerint, impediunt directam telorum
9 missionem. Item theatri vasa aerea, quae in cellis
sub gradibus mathematica ratione conlocantur
quae Graeci *ēcheia* appellant; sonitum et discrimina
ad symphonias musicas sive concentus componuntur
divisa in circinatione diatessaron et diapente et
disdiapason, uti vox scaenici sonitus conveniens in
dispositionibus tactu cum offenderit, aucta cum
incremento clarior et suavior ad spectatorum per-
veniat aures. Hydraulicas quoque machinas et
cetera, quae sunt similia his organis, sine musicis
10 rationibus efficere nemo poterit. Disciplinam vero
medicinae novisse oportet propter inclinationem
caeli, quae Graeci *climata* dicunt, et aeris et locorum,
qui sunt salubres aut pestilentes, aquarumque usus;
sine his enim rationibus nulla salubris habitatio
fieri potest. Iura quoque nota habeat oportet, ea
quae necessaria sunt aedificiis communibus parietum
ad ambitum stillicidiorum et cloacarum, luminum.

¹ suculis *Joc.*

² utraque *rec.*

³ homotona *Phil.*

¹ Philander's reading *homotona*, "equal tones," is tempting.

² Book V. v. 7.

³ Book X.

⁴ These subjects are treated in Hippocrates, *de aere aquis locis*.

⁵ "The right of blocking the lights of a neighbour's house, of running water or dropping water," Gaius, II. 14. Cicero's

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beams on right and left are holes "of half-tones" (*hemitonia*)¹ through which ropes twisted out of thongs are stretched by windlasses and levers. And these ropes are not shut off nor tied up, unless they make clear and equal sounds in the ear of the craftsman. For the arms which are shut up under those strains, when they are stretched out, ought to furnish an impetus evenly, and alike on either side. But if they do not give an equal note, they will hinder the straight direction of the missiles. 9. In theatres, also, are copper vessels and these are placed in chambers under the rows of seats in accordance with mathematical reckoning. The Greeks call them *echeia*.² The differences of the sounds which arise are combined into musical symphonies or concords: the circle of seats being divided into fourths and fifths and the octave. Hence, if the delivery of the actor from the stage is adapted to these contrivances, when it reaches them, it becomes fuller, and reaches the audience with a richer and sweeter note. Or again, no one who lacks a knowledge of music can make water-engines³ or similar machines. 10. Again, he must know the art of medicine⁴ in its relation to the regions of the earth (which the Greeks call *climata*); and to the characters of the atmosphere, of localities (wholesome or pestilential), of water-supply. For apart from these considerations, no dwelling can be regarded as healthy. He must be familiar with the rights or easements which necessarily belong to buildings with party walls, as regards the range of eaves-droppings, drains and lighting.⁵ The water-supply, also, and other

phrase *iura parietum, luminum, stillicidiorum, de Or.* I. 173, exactly corresponds to Vitruvius.

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Item, aquarum ductiones et cetera, quae eiusmod sunt, nota oportet sint architectis, uti ante caveant quam instituant aedificia, ne controversiae factis operibus patribus familiarum relinquantur, et ut legibus scribendis prudentia cavere possit et locatori et conductori; namque si lex perite fuerit scripta, erit ut sine captione uterque ab utroque liberetur. Ex astrologia autem cognoscitur oriens, occidens, meridies, septentrio, etiam caeli ratio, aequinoctium, solstitium, astrorum cursus; quorum notitiam si quis non habuerit, horologiorum rationem omnino scire non poterit.

- 11 Cum ergo tanta haec disciplina sit, condecorata et abundans eruditionibus variis ac pluribus, non puto posse iuste repente profiteri architectos, nisi qui ab aetate puerili his gradibus disciplinarum scandendo scientia plerarumque¹ litterarum et artium nutriti pervenerint ad summum templum architecturae.
- 12 Ac fortasse mirum videbitur inperitis hominibus posse naturam tantum numerum doctrinarum perdiscere et memoria continere. Cum autem animadverterint omnes disciplinas inter se coniunctionem rerum et communicationem habere, fieri posse faciliter credent; encyclios enim disciplina uti corpus unum ex his membris est composita. Itaque qui a teneris aetatibus eruditionibus variis instruuntur, omnibus litteris agnoscunt easdem notas communicationemque omnium disciplinarum, et ea re facilius omnia cognoscunt. Ideoque de veteribus architectis

¹ plerarumque *Frisemann* : plerumque *H.*

¹ *lex* denotes all kinds of contracts.

² Book IX.

³ Cicero groups together medicine, architecture, and teaching as honourable to persons of a lower class. *Off.* I. 151.

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related matters, ought to be familiar to architects: so that, before building is begun, precautions may be taken, lest on completion of the works the proprietors should be involved in disputes. Again, in writing the specifications,¹ careful regard is to be paid both to the employer and to the contractor. For if the specification is carefully written, either party may be released from his obligations to the other, without the raising of captious objections. By astronomy we learn the east, the west, the south and the north; also the order of the heavens, the equinox, the solstice, the course of the planets. For if anyone is unfamiliar with these, he will fail to understand the construction of clocks.²

11. Since, therefore, so great a profession³ as this is adorned by, and abounds in, varied and numerous accomplishments, I think that only these persons can forthwith justly claim to be architects who from boyhood have mounted by the steps of these studies and, being trained generally in the knowledge of arts and the sciences, have reached the temple of architecture at the top. 12. But perhaps it will seem wonderful to inexperienced persons that human nature can master and hold in recollection so large a number of subjects. When, however, it is perceived that all studies are related to one another and have points of contact, they will easily believe it can happen. For a general education is put together like one body from its members. So those who from tender years are trained in various studies recognise the same characters in all the arts and see the intercommunication of all disciplines, and by that circumstance more easily acquire general information. And, therefore, one

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Pythius, qui Prieni¹ aedem Minervae nobiliter est architectatus, ait in suis commentariis architectum omnibus artibus et doctrinis plus oportere posse facere, quam qui singulas res suis industriis et exercitationibus ad summam claritatem perduxerunt.

- 13 Id autem re non expeditur. Non enim debet nec potest esse architectus grammaticus, uti fuerit Aristarchus, sed non agrammatus, nec musicus ut Aristoxenus, sed non amusus, nec pictor ut Apelles, sed graphidos non inperitus, nec plastes quemadmodum Myron seu Polyclitus, sed rationis plasticae non ignarus, nec denuo medicus ut Hippocrates, sed non aniatrologicus,² nec in ceteris doctrinis singulariter excellens, sed in is³ non inperitus. Non enim in tantis rerum varietatibus elegantias singulares quisquam consequi potest, quod earum ratiocinationes cognoscere et percipere vix cadit in potestatem.
- 14 Nec tamen non tantum architecti non possunt in omnibus rebus habere summum effectum, sed etiam ipsi qui privatim proprietates tenent artium, non efficiunt,⁴ ut habeant omnes summum laudis principatum. Ergo si in singulis doctrinis singuli artifices neque omnes sed pauci aevo perpetuo nobilitatem vix sunt consecuti, quemadmodum potest architectus, qui pluribus artibus debet esse peritus, non id ipsum mirum et magnum facere, ne quid ex his

¹ prieni *H* : primus $\frac{1}{2}$ prieni *G*.

² aniatrologetus *H*^c*G* : -gecus *H*.

³ his *H*.

⁴ efficiunt *H*.

¹ Of Alexandria, Librarian of the Museum, c. 150 B.C.; first defined the eight parts of speech.

² Book V. iv.

³ Of Colophon: greatest painter of antiquity, especially of portraits, c. 350 B.C.

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of the old architects Pythius, who was the designer of the noble temple of Minerva at Priene, says in his Commentaries that an architect ought to be able to do more in all arts and sciences than those who, by their industry and experience, have advanced individual arts to the highest renown. But that is not in fact established. 13. For an architect ought to be and can be no critic like Aristarchus,¹ yet not without culture; no musician like Aristoxenus,² yet not without knowledge of music; no painter like Apelles,³ yet not unskilled with his pencil; no sculptor like Myron⁴ or Polyclitus,⁵ yet not ignorant of the plastic art; nor in fine a physician like Hippocrates,⁶ yet not unskilled in medicine; nor in other sciences excelling in a singular manner, yet in these not unskilled. For in so great a variety of things no one can in every case attain minute perfection, because it scarcely falls into his power to acquire and understand their methods. 14. Yet while architects are thus not able in every art to achieve the highest perfection, even those who severally possess the qualities of the craftsman do not all succeed in reaching supreme mastery. Therefore, since in each art, single craftsmen, not all, but few throughout the ages have scarcely attained renown, why should not an architect, who has to be skilled in several arts, count it a fine achievement if he is not deficient in anything belonging to them? How can he hope

⁴ Of the Attic school, early fifth century B.C., sculptor of the Discobolus.

⁵ Of the Argive school, later fifth century B.C., sculptor of the Doryphorus, which established a canon of human proportion.

⁶ Hippocrates, born c. 460 B.C., founded a medical school at Cos.

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- indigeat, sed etiam ut omnes artifices superet qui singulis doctrinis adsiduitatem cum industria summa
 15 praestiterunt? Igitur in hac re Pythius errasse videtur, quod non animadvertit ex duabus rebus singulas artes esse compositas, ex opere et eius ratiocinatione, ex his autem unum proprium esse eorum qui singulis rebus sunt exercitati, id est operis effectus, alterum commune cum omnibus doctis, id est rationem, uti medicis et musicis et de venarum rythmo¹ ad pedem motus, ut si vulnus mederi aut aegrum eripere de periculo oportuerit, non accedet musicus, sed id opus proprium erit medici; item in organo non medicus sed musicus modulabitur, ut aures suae cantionibus recipiant
 16 iucunditatem. Similiter cum astrologis et musicis est disputatio communis de sympathia stellarum et symphoniarum in quadratis et trigonis² diatessaron et diapente, a geometris de visu qui graece *logos opticos* appellatur; ceterisque omnibus doctrinis multae res vel omnes communes sunt dumtaxat ad disputandum. Operum vero ingressus qui manu aut tractationibus ad elegantiam perducuntur, ipsorum sunt, qui proprie una arte ad faciendum sunt instituti. Ergo satis abunde videtur fecisse, qui ex singulis doctrinis partes et rationes earum mediocriter habet notas, eas quae necessariae sunt ad architecturam, uti, si quid de his rebus et artibus
 17 iudicare et probare opus fuerit, ne deficiatur. Qui-

¹ pythmo *H.*

² tridonis *H.*

¹ Geometers as well as those who treat vision from the psychological standpoint.

² This, the reading of *H.*, has been wrongly changed by some editors; cf. *supra*, § 4.

³ *supra*, § 1.

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for so great and remarkable a thing as to surpass craftsmen who have assiduously and with the greatest industry applied themselves to single employments? 15. Therefore in this matter Pythius seems to have erred because he failed to perceive that the several arts are composed of two things—craftsmanship and the theory of it. Of these the one, craftsmanship, is proper to those who are trained in the several arts, namely, the execution of the work; the other, namely, theory, is shared with educated persons. Physician and musician alike deal with the rhythm of the pulse and the movement of the feet. For example, if a man has to heal a wound or to rescue a sick man out of danger, it is not the musician who will come, but it will be the special work of a physician. So also in the case of a musical instrument, a musician and not a physician will be in control so that one's ears may receive the sweetness of a song. 16. Likewise there is a question common to astronomers and musicians about the sympathy of stars and of the concords, fourths and fifths, in quadrants and triangles; and geometers¹ treat about vision, which in Greek is called *logos opticos*²; thus throughout all the sciences many things, or indeed all, are in common so far as theory is concerned. But the taking up of work which is finely executed by hand,³ or technical methods, belongs to those who have been specially trained to work in a single trade. Therefore, he seems to have done quite enough who in the several arts is moderately familiar with the branches and methods which are necessary to architecture, so that he is not at a loss when it is necessary to judge and test any work done in these other departments and trades. 17. But those individuals

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bus vero natura tantum tribuit sollertiae, acuminis, memoriae, ut possint geometriam, astrologiam, musicen ceterasque disciplinas penitus habere notas, praetereunt officia architectorum et efficiuntur mathematici. Itaque faciliter contra eas disciplinas disputare possunt, quod pluribus telis disciplinarum sunt armati. Hi autem inveniuntur raro, ut aliquando fuerunt Aristarchus Samius, Philolaus et Archytas Tarentini, Apollonius Pergaeus, Eratosthenes Cyrenaeus, Archimedes et Scopinas ab Syracusis, qui multas res organicas, gnomonicas numero naturalibusque rationibus inventas atque explicatas posteris reliquerunt.

- 18 Cum ergo talia ingenia ab naturali sollertia non passim cunctis gentibus sed paucis viris habere concedatur, officium vero architecti omnibus eruditionibus debeat esse exercitatum, et ratio propter amplitudinem rei permittat non iuxta necessitatem summas sed etiam mediocris¹ scientias habere disciplinarum, peto, Caesar, et a te et ab is, qui ea volumina sunt lecturi, ut, si quid parum ad regulam artis grammaticae fuerit explicatum, ignoscatur. Namque non uti summus philosophus nec rhetor disertus nec grammaticus summis rationibus artis exercitatus, sed ut architectus his litteris inbutus haec nisus sum scribere. De artis vero potestate quacque insunt in ea ratiocinationes polliceor, uti spero, his voluminibus non modo aedificantibus sed

¹ mediocris *H.*

¹ Celebrated mathematician at Alexandria, c. 275 B.C.

² Contemporary of Plato, Pythagorean philosopher.

³ Followed Euclid at Alexandria.

⁴ Encyclopedic mathematician, astronomer and geographer. Librarian of the Museum at Alexandria, died c. 195 B.C.

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on whom nature has bestowed so much skill, acumen, retentiveness that they can be thoroughly familiar with geometry, astronomy, music and other studies, go beyond the duties of an architect and are to be regarded as mathematicians. And thus they can easily dispute about those subjects because they are armed with the weapons provided by their studies. Such men, however, are rarely met. We can point to Aristarchus¹ of Samos; Philolaus² and Archytas² of Tarentum; Apollonius³ of Perga; Eratosthenes⁴ of Cyrene; Archimedes⁵ and Scopinas⁶ from Syracuse. They have left to after times many treatises on machinery and clocks, in which mathematics and natural laws are used to discover and explain.

18. Yet it is not granted to nations as a whole, but only to few individuals, to have such genius owing to their natural endowment. At the same time the architect in his work ought to be practised in all accomplishments. Yet reason, in view of the scope of the matter, does not permit us, as need demands, to have a complete, but only a moderate, knowledge of the various subjects involved. Hence I beg your Highness and the other readers of these volumes to pardon any explanation that too little agrees with the rules of the literary art. For it is not as a lofty thinker, nor as an eloquent speaker, nor as a scholar practised in the best methods of literary criticism, but as an architect who has a mere tinge of these things, that I have striven to write the present treatise. But in respect to the meaning of my craft and the principles which it involves, I hope and undertake to expound them

⁵ Killed at siege of Syracuse, 212 B.C.

⁶ Invented a sundial placed in the Circus Flaminius.

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etiam omnibus sapientibus cum maxima auctoritate me sine dubio praestaturum.

II

1 ARCHITECTURA autem constat ex ordinatione, quae graece *taxis* dicitur, et ex dispositione, hanc autem Graeci *diathesisin* vocitant, et eurythmia et symmetria et decore et distributione quae graece *oeconomia* dicitur.

2 Ordinatio est modica membrorum operis commoditas separatim univarseque proportionis¹ ad symmetriam comparatio. Haec componitur ex quantitate, quae graece *posotes*² dicitur. Quantitas autem est modulorum ex ipsius operis sumptio e singulisque membrorum partibus universi operis conveniens effectus.

Dispositio autem est rerum apta conlocatio elegansque³ conpositionibus effectus operis cum qualitate. Species dispositionis, quae graece dicuntur *ideae*, sunt hae: ichnographia, orthographia, scaenographia. Ichnographia est circini regulaeque modice continens usus, e qua⁴ capiuntur formarum in solis⁵ arearum descriptiones. Orthographia autem est erecta frontis imago modiceque picta rationibus

¹ proportionis *S.*

³ elegans *H.*

⁵ solis *G*: soliis *H.*

² possotes *H.*

⁴ equa *G*: aequa *H.*

¹ *taxis* and *oeconomia* are mentioned together by the author of the treatise *On the Sublime*, I. 4. Vitruvius assembles terms of aesthetic criticism without clearly distinguishing. Wordsworth's phrase "proportion and congruity" indicates the essence of the classical manner (*Prose Works*, II. 127).

BOOK I. C. I.—C. II.

with assured authority, not only to persons engaged in building but also to the learned world.

CHAPTER II

OF WHAT THINGS ARCHITECTURE CONSISTS

1. Now architecture consists of Order, which in Greek is called *taxis*,¹ and of Arrangement, which the Greeks name *diathesis*, and of Proportion and Symmetry and Decor and Distribution which in Greek is called *oeconomia*.²

2. Order is the balanced adjustment of the details of the work separately, and, as to the whole, the arrangement of the proportion with a view to a symmetrical result. This is made up of Dimension, which in Greek is called *posotes*. Now Dimension is the taking of modules³ from the parts of the work; and the suitable effect of the whole work arising from the several subdivisions of the parts.

Arrangement, however, is the fit assemblage of details, and, arising from this assemblage, the elegant effect of the work and its dimensions, along with a certain quality or character. The kinds of the arrangement (which in Greek are called *ideae*) are these: ichnography (plan); orthography (elevation); scenography (perspective). Ichnography (plan) demands the competent use of compass and rule; by these plans are laid out upon the sites provided. Orthography (elevation), however, is the vertical image of the front, and a figure slightly

² Vitruvius' three terms seem to correspond to Democritus' *ordo positura figurae* given in Lucretius, I. 685.

³ Units of Measurement.

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operis futuri figura. Item scaenographia est frontis et laterum abscedentium adumbratio ad circinique centrum omnium linearum responsus. Hae nascuntur ex cogitatione et inventione. Cogitatio est cura studii plena et industriae vigilantiaque effectus propositi cum voluptate. Inventio autem est quaestionum obscurarum explicatio ratioque novae rei vigore mobili reperta. Hae sunt terminationes dispositionum.

- 3 Eurythmia est venusta species commodusque in compositionibus membrorum aspectus. Haec efficitur, cum membra operis convenientia sunt altitudinis ad latitudinem, latitudinis ad longitudinem, et ad summam omnia respondent ¹ suae symmetriae.
- 4 Item symmetria est ex ipsius operis membris conveniens consensus ex partibusque separatis ad universae figurae speciem ratae ² partis responsus. Uti in hominis corpore e cubito, pede, palmo, digito ceterisque particulis symmetros est eurythmiae qualitas, sic est in operum perfectionibus. Et primum in aedibus sacris aut e columnarum crassitudinibus aut triglypho aut etiam embatere, ballista e foramine, quod Graeci *peritreton* vocitant, navibus interscaltio, quae *dipechyaia* ³ dicitur, item ceterorum operum e membris invenitur symmetriarum ratiocinatio.

Decor autem est emendatus operis aspectus probatis rebus compositi cum auctoritate. Is perficitur

¹ respondent *G*: -deant *H*.

² ratae *G*: latae *H*.

³ διπηχυαία *Sch*: dipheciaca *H*.

¹ As in the canon of Polyclitus, Book I. i. 13.

² Seems to denote architectural good manners or decorum in detail as well as generally.

BOOK I. c. II.

tinted to show the lines of the future work. Scenography (perspective) also is the shading of the front and the retreating sides, and the correspondence of all lines to the vanishing point, which is the centre of a circle. These three (plan, elevation and perspective) arise from imagination and invention. Imagination rests upon the attention directed with minute and observant fervour to the charming effect proposed. Invention, however, is the solution of obscure problems; the treatment of a new undertaking disclosed by an active intelligence. Such are the outlines of Arrangement.

3. Proportion implies a graceful semblance; the suitable display of details in their context. This is attained when the details of the work are of a height suitable to their breadth, of a breadth suitable to their length; in a word, when everything has a symmetrical correspondence.

4. Symmetry also is the appropriate harmony arising out of the details of the work itself; the correspondence of each given detail among the separate details to the form of the design as a whole. As in the human body, from cubit, foot, palm, inch and other small parts comes the symmetric quality of eurhythmy¹; so is it in the completed building. First, in sacred buildings, either from the thickness of columns, or a triglyph, or the module; of a balista by the perforation which the Greeks call *peritreton*; by the space between the rowlocks in a ship which is called *dipechyaia*: so also the calculation of symmetries, in the case of other works, is found from the details.

5. Decor² demands the faultless ensemble of a work composed, in accordance with precedent, of

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statione, quod graece *thematismo* dicitur, seu consuetudine aut natura. Statione, cum Iovi Fulguri et Caelo et Soli et Lunae aedificia sub divo hypaethraque constituentur; horum enim deorum et species et effectus in aperto mundo atque lucenti praesentes vidimus.¹ Minervae et Marti et Herculi aedes doricae fient; his enim diis propter virtutem sine deliciis² aedificia constitui decet. Veneri, Florae, Proserpinae, Fonti Lumphis³ corinthio genere constitutae aptas videbuntur habere proprietates, quod his diis propter teneritatem graciliora et florida foliisque et volutis ornata opera facta augere videbuntur iustum decorem. Iunoni, Dianae, Libero Patri ceterisque diis qui eadem sunt similitudine, si aedes ionicae construentur, habita erit ratio mediocritatis, quod et ab severo more doricorum et ab teneritate corinthiorum temperabitur
6 eorum institutio proprietatis. Ad consuetudinem autem decor sic exprimitur, cum aedificiis interioribus magnificis item vestibula convenientia et elegantia erunt facta. Si enim interiora prospectus⁴ habuerint elegantes, aditus autem humiles et inhonestos, non erunt cum decore. Item si doricis epistyliis in coronis denticuli sculpsuntur aut in pulvinatis columnis et ionicis epistyliis [capitulis]⁵ exprimentur triglyphi,⁶ translatis ex alia ratione proprietatibus in aliud genus operis offendetur aspectus aliis ante ordinis consuetudinibus institutis.

¹ videmus *G*: vidimus *H*.

² deliciis (-as *H*) *H G*.

³ Lumphis *Ro*: fontycumphys *H*.

⁴ prospectus *rec*: perfectus *H*.

⁵ capitulis *del. Ro*.

⁶ triglyphi *Joc*: triglyphis *G*: triclyphis *H*.

BOOK I. c. II.

approved details. It obeys convention, which in Greek is called *thematismos*, or custom or nature. Convention is obeyed when buildings are put up in the open and hypethral to Jupiter of the Lightning, to Heaven, the Sun, the Moon; for of these gods, both the appearance and effect we see present in the open, the world of light. To Minerva, Mars and Hercules, Doric temples will be built; for to these gods, because of their might, buildings ought to be erected without embellishments. Temples designed in the Corinthian style will seem to have details suited to Venus, Flora, Proserpine, Fountains, Nymphs; for to these goddesses, on account of their gentleness, works constructed with slighter proportions and adorned with flowers, foliage, spirals and volutes will seem to gain in a just decor. To Juno, Diana and Father Bacchus, and the other gods who are of the same likeness, if Ionic temples are erected, account will be taken of their middle quality; because the determinate character of their temples will avoid the severe manner of the Doric and the softer manner of the Corinthian. 6. With reference to fashion, decor is thus expressed; when to magnificent interiors vestibules also are made harmonious and elegant. For if the interior apartments present an elegant appearance, while the approaches are low and uncomely, they will not be accompanied by fitness. Again, if, in Doric entablatures, dentils are carved on the cornices, or if with voluted capitals and Ionic entablatures, triglyphs are applied, characteristics are transferred from one style to another: the work as a whole will jar upon us, since it includes details foreign to the order.¹ 7. There will

¹ This rule is generally observed in modern architecture.

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- 7 Naturalis autem decor sic erit, si primum omnibus templis saluberrimae regiones aquarumque fontes in his locis idonei eligentur, in quibus fana constuantur, deinde maxime Aesculapio, Saluti, et eorum deorum quorum plurimi medicinis aegri curari videntur. Cum enim ex pestilenti in salubrem locum corpora aegra translata fuerint et e fontibus salubribus aquarum usus subministrabuntur, celerius convalescent. Ita efficietur, uti ex natura loci maiores auctasque cum dignitate divinitas excipiat opiniones. Item naturae decor erit, si cubiculis et bybliotheis ab oriente lumina capiuntur, balneis et hibernaculis ab occidente hiberno, pinacothecis ¹ et quibus certis luminibus opus est partibus, a septentrione, quod ea caeli regio neque exclaratur neque obscuratur solis cursu sed est certa inmutabilis die perpetuo.
- 8 Distributio autem est copiarum locique commoda dispensatio parcaque in operibus sumptus ratione temperatio. Haec ita observabitur, si primum architectus ea non quaeret, quae non potuerunt ² inveniri aut parari nisi magno. Namque non omnibus locis harenae fossiciae nec caementorum nec abietis nec sappinorum nec marmoris copia est, sed aliud alio loco nascitur, quorum conportationes difficiles sunt

¹ pinacothicis *H.*

² potuerunt *H.*

¹ The Temple of Aesculapius on the Isola Tiberina contained votive offerings of limbs in terracotta presented by sick persons.

² Cicero's architect justifies the narrowness of windows by reference to a theory of vision based on Democritus or (less probably) Epicurus, *ad. Att.* II. 3.

BOOK I. c. II.

be a natural decor: first, if for all temples there shall be chosen the most healthy sites with suitable springs in those places in which shrines are to be set up; secondly and especially for Aesculapius¹ and Salus; and generally for those gods by whose medical power sick persons are manifestly healed. For when sick persons are moved from a pestilent to a healthy place and the water supply is from wholesome fountains, they will more quickly recover. So will it happen that the divinity (from the nature of the site) will gain a greater and higher reputation and authority.

OF DOORS AND WINDOWS IN BATHS AND ELSEWHERE

Also there will be natural seemliness if light² is taken from the east for bedrooms and libraries; for baths and winter apartments, from the wintry sunset; for picture galleries and the apartments which need a steady light, from the north, because that quarter of the heavens is neither illumined nor darkened by the sun's course but is fixed unchangeable throughout the day.

ON THE QUALITIES OF SITES AND SUPPLIES FOR THE WORKS

8. Distribution or Economy, however, is the suitable disposal of supplies and the site, and the thrifty and wise control of expense in the works. This will be guarded if, in the first place, the architect does not require what can only be supplied and prepared at great cost. For it is not everywhere that there is a supply of quarry sand or hewn stone, or fir or deal or marble. Different things are found in different places, the transport of them may be difficult

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et sumptuosae. Utendum autem est, ubi non est harena fossicia, fluviatica aut marina lota; inopiae quoque abietis aut sappinorum vitabuntur utendo cupresso, populo, ulmo, pinu; reliquaque his simili⁹ liter erunt explicanda. Alter gradus erit distributionis, cum ad usum patrum familiarum et ad pecuniae copiam aut ad eloquentiae dignitatem aedificia alte disponentur. Namque aliter urbanas¹ domos oportere constitui videtur, aliter quibus ex possessionibus rusticis influunt fructus; non idem feneratoribus, aliter beatis et delicatis; potentibus vero, quorum cogitationibus respublica gubernatur, ad usum conlocabuntur; et omnino faciendae sunt aptae omnibus personis aedificiorum distributiones.

III

- 1 PARTES ipsius architecturae sunt tres: aedificatio, gnomonice, machinatio. Aedificatio autem divisa est bipertito, e quibus una est moenium et communium operum in publicis locis conlocatio, altera est privatorum aedificiorum explicatio. Publicorum autem distributiones sunt tres, e quibus est una² defensionis, altera religionis, tertia opportunitatis. Defensionis est murorum turriumque et portarum ratio ad hostium impetus perpetuo repellendos excogitata, religionis deorum immortalium fanorum

¹ urbanos *G*.

² est una *H*: una est *G*.

¹ Horace describes the financier in the country, *Epode* II.

² Cicero spent enormous sums on his palaces.

³ *Infra*, c. v.

BOOK I. c. II.—c. III.

and costly. Now where there is no quarry sand we must use washed river or sea sand; the need for fir or deal will be met by using cypress, poplar, elm, pine; other difficulties will be solved in a like fashion.

9. The second stage in Economy comes, when buildings are variously disposed for the use of owners or with a view to the display of wealth or lofty enough to suit the most dignified eloquence. For manifestly houses should be arranged in one way in towns; in another way for persons whose income arises from country estates; not the same for financiers;¹ in another way for the wealthy men of taste; for the powerful, however, by whose ideas the state is governed, there must be special adjustment to their habits.² And generally the distribution of buildings is to be adapted to the vocations of their owners.

CHAPTER III

ON THE PARTS OF ARCHITECTURE

1. THE parts of architecture itself are three: Building (Books I–VIII), Dialling (Book IX), and Mechanics (Book X). Building in turn is divided into two parts; of which one is the placing of city walls, and of public buildings on public sites (Books I–V); the other is the setting out of private buildings (Books VI–VIII). Now the assignment of public buildings is threefold: one, to defence; the second, to religion; the third, to convenience. The method of defence by walls, towers and gates has been devised with a view to the continuous warding off of hostile attacks³; to religion belongs the placing of the shrines and sacred temples of the immortal

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aediumque sacrarum conlocatio, opportunitatis communium locorum ad usum publicum dispositio,¹ uti portus, fora, porticus, balinea,² theatra, inambulationes ceteraque, quae isdem rationibus in publicis locis³ designantur.

- 2 Haec autem ita fieri debent, ut habeatur ratio firmitatis, utilitatis, venustatis. Firmitatis erit habita ratio, cum fuerit fundamentorum ad solidum depressio, quaque e materia, copiarum sine avaritia diligens electio; utilitatis autem, <cum fuerit>⁴ emendata et sine inpeditione usus⁵ locorum dispositio et ad regiones sui cuiusque generis apta et comoda distributio; venustatis vero, cum fuerit operis species grata et elegans membrorumque commensus iustas habeat symmetriarum ratiocinationes.

IV

- 1 In ipsis vero moenibus ea erunt principia. Primum electio loci saluberrimi. Is autem erit excelsus et non nebulosus, non pruinosis regionesque caeli spectans neque aestuosas neque frigidas sed temperatas, deinde sic vitabitur palustris vicinitas. Cum enim aurae matutinae cum sole oriente ad oppidum pervenient et his ortae nebulae adiungentur spiritusque bestiarum palustrum venenatos cum nebula mixtos in habitatorum corpora flatu spargent, efficient locum pestilentem. Item si secundum mare

¹ uti *H* : ut *G*.

³ locis *om.* *H*.

⁵ usus *rec* : usu *H*.

² balinea *H* : balnea *H*G*.

⁴ *add. Mar.*

¹ Books III and IV.

² Book V.

³ Vitruvius follows Varro, *de re rustica* (on Farming),

BOOK I. c. III.—c. IV.

gods¹; to convenience, the disposal of public sites for the general use,² such as harbours, open spaces, colonnades, baths, theatres, promenades, and other things which are planned, with like purposes, in public situations.

2. Now these should be so carried out that account is taken of strength, utility, grace. Account will be taken of *strength* when the foundations are carried down to the solid ground, and when from each material there is a choice of supplies without parsimony; of *utility*, when the sites are arranged without mistake and impediment to their use, and a fit and convenient disposition for the aspect of each kind; of *grace*, when the appearance of the work shall be pleasing and elegant, and the scale of the constituent parts is justly calculated for symmetry.

CHAPTER IV

ON THE SALUBRITY OF SITES³

1. IN the case of the walls these will be the main points:—First, the choice of the most healthy site. Now this will be high and free from clouds and hoar frost, with an aspect neither hot nor cold but temperate. Besides, in this way a marshy neighbourhood shall be avoided. For when the morning breezes come with the rising sun to a town, and clouds rising from these shall be conjoined, and, with their blast, shall sprinkle on the bodies of the inhabitants the poisoned breaths of marsh animals, they will make the site pestilential. Also if the

I. xii. 2, who says that in marshy places, minute and invisible animals grow and cause diseases. The anticipation of the true cause of malaria (mosquitoes) is noteworthy.

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erunt moenia spectabuntque ad meridiem aut occidentem, non erunt salubria, quod per aestatem caelum meridianum sole exoriente calescit meridie ardet; item quod spectat ad occidentem, sole exorto
2 tepescit, meridie calet, vespere fervet. Igitur mutationibus caloris et refrigerationis corpora, quae in his locis sunt, vitiantur. Hoc autem licet animadvertere etiam ex is, quae non sunt animalia. In cellis enim vinariis tectis lumina nemo capit a meridie nec ab occidente, sed a septentrione, quod ea regio nullo tempore mutationes recipit sed est firma perpetuo et inmutabilis. Ideo etiam et granaria quae ad solis cursum spectant, bonitatem cito mutant, obsoniaque et poma, quae non in ea parte caeli ponuntur, quae est aversa a solis cursu, non diu
3 servantur. Nam semper calor cum excoquit aeribus firmitatem et vaporibus fervidis eripit exsugendo naturales virtutes; dissolvit eas et fervore mollescentes efficit inbecillas. Ut etiam in ferro animadvertimus, quod, quamvis natura sit durum, in fornacibus ab ignis vapore percalefactum ita mollescit, uti in omne¹ genus formae faciliter fabricetur; et idem, cum molle et candens refrigeretur tinctum frigida, redurescat et restituatur in antiquam pro-
4 prietatem. Licet etiam considerare haec ita esse ex eo, quod aestate non solum in pestilentibus locis sed etiam in salubribus omnia corpora calore fiant inbecilla, et per hiemem etiam quae pestilentissimae sint regiones efficiantur salubres, ideo quod a refrigerationibus solidantur. Non minus etiam quae ab frigidis regionibus corpora traducuntur in calidas,

¹ omni *H.*

BOOK I. c. iv.

walls are along the coast and shall look to the south or west they will not be wholesome, because through the summer the southern sky is warmed by the rising sun and burns at midday. Also that which looks to the western sun is warm at sunrise, hot at noon, burns in the evening. 2. Therefore by the changes of heat and cold, bodies which are in these places will be infected. We may even perceive this from those bodies which are not animal. For in wine stores no one takes light from the south or west but from the north, because that quarter at no time admits changes, but is continuously fixed and unchangeable. So also those granaries which look towards the sun's course quickly change their goodness; and fish and fruit which are not placed in that quarter which is turned away from the sun's course do not keep long. 3. For always, when heat cooks the strength out of the atmosphere and with warm vapours removes by suction the natural virtues, it dissolves and renders them weak, as they become softened by warmth. Moreover, we see the same thing in iron, which is hard by nature, and yet when it is heated through in furnaces, by the vapour of fire becomes so soft that it is easily fashioned into every kind of shape; and when, being soft and red-hot, it is chilled and steeped in cold water, it hardens again and is restored to its previous character. 4. We may also consider that this is so from the fact that in summer, not only in pestilential, but in salubrious districts, all bodies become weak by the heat; and also, through the winter, even the regions which are most pestilential, are rendered salubrious because they are rendered solid by freezing. Not less also the bodies which are transferred from cold

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- non possunt durare sed dissolvuntur; quae autem ex calidis locis sub septentrionum regiones frigidas, non modo non laborant inmutatione loci valitu-
 5 dinibus sed etiam confirmantur. Quare cavendum esse videtur in moenibus conlocandis ab his regionibus quae caloribus flatus ad corpora hominum possunt spargere. Namque e¹ principiis quae Graeci *stoicheia*² appellant, ut omnia corpora sunt composita, id est e calore et umore, terreno et aere, et ita mixtionibus naturali temperatura figurantur omnium animalium in mundo generatim qualitates.
- 6 Ergo in quibus corporibus cum exsuperat e principiis calor, tunc interficit dissolvitque cetera fervore. Haec autem vitia efficit fervidum ab certis³ partibus caelum, cum insidit in apertas venas plus quam patitur e mixtionibus naturali temperatura corpus. Item si umor occupavit corporum venas inpaesque eas fecit, cetera principia ut a liquido⁴ corrupta diluuntur, et dissolvuntur compositionibus virtutes. Item haec e refrigerationibus umoris ventorum et aurarum infunduntur vitia corporibus. Non minus aeris etiamque terreni in corpore naturalis compositio augendo aut minuendo infirmat cetera principia terrena cibi plenitate, aer gravitate caeli.
- 7 Sed si qui voluerit diligentius haec sensu percipere, animadvertat attendatque⁵ naturas avium et piscium

¹ e *add. rec*: om. *H*.

² *stoechia H*.

³ *certis ed*: caeteris *H*.

⁴ *liquido Kr*: ut *aliquida H*, ut *liquida G*.

⁵ *attendat Joc*: *tendat H*, *intendat G*.

¹ *flatus* = *πνεύματα*.

² *Lit.* "things in a series or row"; hence *elements* or *parts*

BOOK I. c. iv.

to warm regions cannot endure but are dissolved; while those which are transferred from warm places under the northern regions not only do not suffer in health by the change of place but even are strengthened. 5. Wherefore in laying out walls we must beware of those regions which by their heat can diffuse vapours¹ over human bodies. For according as from the elements (which the Greeks call *stoecheia*)² all bodies are composed, that is from heat and moisture and earth and air, just so by these mixtures, owing to natural temperament, the qualities of all animals are figured in the world according to their kind. 6. Therefore in whatsoever bodies, one of their principles, heat, is predominant, it then kills them and by its fervency dissolves the rest. Now a hot sky from certain quarters produces these defects; since it settles into the open veins more than the body permits by its natural temperament or admixture. Again, if moisture had filled the veins of bodies and altered their dimensions, the other elements, as though decomposed by liquid, are diluted and the virtues dependent on their proportion are dissolved. So also from the chilling of moisture of winds and breezes, vices are infused into bodies. Not less the natural proportion of air and also of the earthy element by increase or diminution weakens the other elements; the earthy by repletion of food, the aerial, by the heavy climate.

7. But if anyone wishes carefully to apprehend these things by perception, let him regard and attend to the natures³ of birds and fishes and land of things. Plato first applied the term to the physical constituents of nature.

¹ St. Paul I. Cor. xv. 39 uses an Ionic word *choinos* for earthy, but he is obviously deriving from the same source.

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et terrestrium animalium, et ita considerabit ¹. discrimina temperaturae. Aliam enim mixtionem habet genus avium, aliam piscium, longe aliter terrestrium natura. Volucres minus habent terreni, minus umoris, caloris temperate, ² aeris multum: igitur levioribus principiis compositae facilius in aeris impetum nituntur. Aquatiles autem piscium naturae, quod temperatae sunt a calido plurimumque et aeris et terreni sunt compositae, sed umoris habent oppido quam paulum, quo minus habent e principiis umoris in corpore, facilius in umore perdurant; itaque cum ad terram perducuntur, animam cum aqua relinquunt. Item terrestria, quod e principiis ab aere caloreque sunt temperata minusque habent terreni plurimumque umoris, quod abundant umidae partes, non
8 diu possunt in aqua vitam tueri. Ergo si haec ita videntur, quemadmodum proposuimus, et e principiis animalium corpora composita sensu percipimus et exsuperationibus aut defectionibus ea laborare dissolvique iudicamus, non dubitamus, quin diligentius quaeri oporteat, uti temperatissimas caeli regiones
9 eligamus, cum quaerenda fuerit in moenium conlocationibus salubritas. Itaque etiam atque etiam veterem revocandam censeo ³ rationem. Maiores enim pecoribus immolatis, quae pascebantur in is locis, quibus aut oppida aut castra stativa constituebantur,

¹ consideravit *H.*

² temperate *G*: -tae *H.*

³ cens & *H.*

¹ Vitruvius' scientific method is both deductive and experimental. The neo-Attic revival in sculpture has a parallel in the revival of Greek science at Rome.

² The fixed camps were to become towns like Chester and Lincoln.

BOOK I. c. iv.

animals, and he will so consider differences of temperament or admixture. For the race of birds has one temperament, fishes another, far otherwise the nature of land animals. Birds have less of the earthy, less of moisture, moderate heat, much air. Therefore being compounded of the lighter principles, they rise more easily against the onrush of the air. But fishes with their watery nature (because they are tempered by heat and are compounded of much air and earth, but have remarkably little moisture), the less they have of the principles of moisture in their frame, the more easily they persist in moisture; and so when they are brought to land they lose their life along with the water. Terrestrial animals, also, because they have a moderate degree of the elements of air and heat, and have less of the earthy and more moisture, inasmuch as they abound in moisture, cannot keep alive long in water. 8. Therefore if these matters are accepted as we have set forth, and if we apprehend by perception that the bodies of animals are compounded of elements, and if we judge that they suffer and are dissolved by excess or defect of them, we do not doubt that we must diligently seek to choose the most temperate regions of climate, since we have to seek healthiness in laying out the walls of cities.

ON INSPECTING THE LIVERS OF ANIMALS FOR TESTING THE QUALITY OF THE AIR

9. Therefore emphatically I vote for the revival of the old method.¹ For the ancients sacrificed the beasts which were feeding in those places where towns or fixed camps² were being placed, and they used to inspect the livers, which if at the first trial

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- inspiciebant iocinera, et si erant livida et vitiosa primo alia immolabant dubitantes utrum morbo an pabuli vitio laesa essent. Cum pluribus experti erant et probaverant integram et solidam naturam iocinerum ex aqua et pabulo, ibi constituebant munitiones; si autem vitiosa inveniebant, iudicio transferebant idem in humanis corporibus pestilentem futuram nascentem in his locis aquae cibique copiam, et ita transmigrabant et mutabant regiones quae-
10 rentes omnibus rebus salubritatem. Hoc autem fieri, uti pabulo ciboque salubres proprietates terrae videntur, licet animadvertere et cognoscere agris Cretensium, qui sunt circa Pothereum flumen, quod est Cretae inter duas civitates Gnoson et Gortynam.¹ Dextra enim et sinistra eius fluminis pascuntur pecora; sed ex his quae pascuntur proxime Gnoson, si quae autem ex altera parte proxime ² Gortynam non, habent apparentem splenem. Unde etiam medici quaerentes de ea re invenerunt in his locis herbam, quam pecora rudendo inminuerunt lienes. Ita eam herbam colligendo curant lienosos hoc medicamento, quod etiam Cretenses *asplenon* vocitant. Ex eo licet scire cibo atque aqua proprietates locorum naturaliter pestilentes aut salubres esse.
- 11 Item si in paludibus moenia constituta erunt, quae paludes secundum mare fuerint, spectabuntque ad septentrionem aut inter septentrionem et orientem, eaeque paludes excelsiores fuerint quam litus mari-

¹ cortynam *H*, cortinam *G*.

² proxime *G*²: -ma *H*.

¹ This argument from analogy requires the retention of *idem* in the text.

² Cnossus, the capital of a pre-Homeric civilisation, which

BOOK I. c. iv.

they were livid and faulty, they went on to sacrifice others, doubting whether they were injured by disease or faulty diet. When they had made trial of many, and had tested the entire and solid nature of the livers in accordance with the water and pasture they established there the fortifications; if, however, they found them faulty, by analogy¹ they judged: that the supply of food and water which was to be found in these places would be pestilential in the case of human bodies. And so they removed elsewhere and changed their quarters, seeking salubrity in every respect. 10. But that it comes about that the salubrious properties of the soil are indicated by fodder and diet, we may take note and learn from the districts of Crete which are about the river Pothereus, which flows between the two towns Cnossus² and Gortyna.³ For cattle feed on the right and left bank of that river. But of these, the cattle which feed next Cnossus have, and those on the other side have not, an enlarged spleen. Whence also physicians inquiring about this matter have found in these places a plant which the cattle bellow for and, by it, lessen their spleens. So they gather this plant and use this medicine to cure the splenetic, which also the Cretans call *asplenon*. Hence we may know by food and water whether the properties of places are pestilential or salubrious.

11. So also if in marshes walls are laid out, and these marshes are along the sea, and they look towards the north or between the north and east, and these marshes are higher than the sea-coast,

covered the islands of the Levant and anticipated the architecture and other arts of later Greece.

³ Succeeded Cnossus as capital of Crete.

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num, ratione videbuntur esse constituta. Fossis enim ductis aquae exitus ad litus, et mare ¹ tempestatibus aucto in paludis redundantia motionibus concitata marisque ² mixtionibus non patitur bestiarum palustrium genera ibi nasci, quaeque de superioribus locis natando proxime litus perveniunt, inconsueta salsitudine necantur. Exemplar autem huius rei Gallicae paludes possunt esse, quae circum Altinum, Ravennam, Aquileiam, aliaque quae in eiusmodi locis municipia sunt proxima paludibus, quod his rationibus
 12 habent incredibilem salubritatem. Quibus autem insidentes sunt paludes et non habent exitus profluentes neque ³ flumina neque per fossas, uti Pomptinae, stando putescunt et umores graves et pestilentes in is locis emittunt.

Item in Apulia oppidum Salpia vetus, quod Diomedes ⁴ ab Troia rediens constituit sive, quemadmodum nonnulli scripserunt, Elpias Rhodius, in eiusmodi locis fuerat conlocatum, ex quo incolae quotannis ⁵ aegrotando laborantes aliquando pervenerunt ad M. Hostilium ab eoque publice petentes impetraverunt, ut his ⁶ idoneum locum ad moenia transferenda conquireret elegeretque. Tunc is moratus non est, sed statim rationibus doctissime quaesitis secundum mare mercatus est possessionem loco salubri ab senatuque populoque R.⁷ petit, ut liceret transferre oppidum, constituitque

¹ mare *H* : mari *G*.

² marique *H*.

³ per (flum.) *om. H*.

⁴ diomedis *H*.

⁵ quodannis *H*.

⁶ ut his *H*, uti his *G*.

⁷ romano *G*, f *H*.

¹ Between Aquileia and Padua.

² Ravenna protected by its marshes.

³ Aquileia, founded 182 B.C., as bulwark on N.E.

BOOK I. c. iv.

they will seem to be reasonably laid out. For if dykes are cut, there is made an outlet of water to the beach; and when the sea is swollen by storms, there is an overflow into the marshes, which being stirred and moved about and mixed with sea salt, does not permit the various kinds of marsh creatures to be born there; moreover, those which, by swimming from higher parts, arrive near the coast, are killed by the unfamiliar saltness. An instance of this may be found in the Gallic marshes which are round Altinum,¹ Ravenna,² Aquileia³ and other townships in like places which are nearest the marshes. For owing to these causes, they have an incredible salubrity. 12. Those places, however, which have stagnant marshes, and lack flowing outlets, whether rivers or by dykes, like the Pomptine marshes, by standing become foul and send forth heavy and pestilent moisture.

ON A FORTIFICATION REMOVED FROM ONE SITE TO ANOTHER

Also in Apulia, the town of Old Salpia (which Diomede returning from Troy established, or, as some have written, Elpias of Rhodes), was situated in such places. Thus the inhabitants suffered every year from various ailments. At length they came⁴ to M. Hostilius, and, making a public request, obtained from him that he should seek out and choose a fit site for transferring their walls. Then he delayed not, but forthwith, after fully ascertaining all the conditions, bought a site in a healthy place, and obtained permission from the senate and Roman people to remove the town. He established the walls

⁴ c. 200 B.C.

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moenia et areas divisit nummoque sestertio singulis municipibus mancipio dedit. His confectis lacum aperuit in mare et portum e lacu municipio perfecit. Itaque nunc Salpini quattuor milia passus progressi ab oppido veteri¹ habitant in salubri loco.

V

- 1 Cum ergo his rationibus erit salubritatis moenium² conlocandorum explicatio regionesque electae fuerint fructibus ad alendam civitatem copiosae, et viarum munitiones aut opportunitates fluminum seu per portus marinae subvectionis habuerit ad moenia conportationes expeditas, tunc turrium murorumque fundamenta sic sunt facienda, uti fodiantur, si queant inveniri, ad solidum et in solido, quantum ex amplitudine operis pro ratione videantur,³ crassitudine ampliore quam parietum qui supra terram sunt futuri, et ea impleantur quam solidissima structura.
- 2 Item turres sunt proiciendae in exteriorem partem, uti, cum ad murum hostis impetu velit adpropinquare, a turribus dextra ac sinistra lateribus apertis telis vulnerentur. Curandumque maxime videtur, ut non facilis aditus sit ad oppugnandum murum, sed ita circumdandum ad loca praecipitia et excogitandum, uti portarum itinera non sint directa sed scaeva. Namque cum ita factum fuerit, tum⁴ dextrum latus accedentibus, quo⁵ scuto non erit tectum proximum

¹ veteri *H* -re *G*; in *H*: om. *G*.

² moenium *Phil*: inmoenium *H*.

³ videatur *G*: -antur *HS*.

⁴ tum *H*: dum *G*.

⁵ quo *HG*.

BOOK I. c. iv.—c. v.

and divided the sites and gave formal possession to the individual townsmen for a sesterce each. When this was done he opened the lake into the sea, and made a harbour out of the lake for the municipality. And so the people of Salpia now dwell on a healthy site at a distance of four miles from the old town.

CHAPTER V

ON THE FOUNDATIONS OF WALLS AND THE ESTABLISHMENT OF TOWNS

1. WHEN, therefore, by these methods there shall be ensured healthiness in the laying out of the walls; and districts shall be chosen abounding in fruit to feed the citizens; and roads duly laid out, or convenient rivers, or supplies by sea through the harbours, shall have ready transport to the ramparts: then the foundations of the towers and walls are to be laid. If such foundations can be found, they are to be dug down to the solid and in the solid, as may seem proportionate to the amplitude of the work, of a breadth greater than that of the walls which shall be above the ground; and these foundations are to be filled with as solid structure as possible. 2. Towers, moreover, are to be projected on the outer side, in order that when the enemy wishes to approach the wall in an attack, he may be wounded on his exposed flanks by weapons on the right and left from the towers. And it seems that care must especially be taken that the approach be not easy for an enemy blockading the wall. The approach must be made to wind along the steep places, and so devised that the ways to the gates are not straight, but on the left

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erit muro. Conlocanda autem oppida sunt non quadrata nec procurrentibus angulis sed circuitionibus, uti hostis ex pluribus locis conspiciatur. In quibus enim anguli procurrunt, difficiliter defenditur, quod
 3 angulus magis hostem tuetur quam civem. Crassitudinem autem muri ita faciendam censeo, uti armati homines supra obviam venientes alius alium sine inpeditione praeterire possint, dum in crassitudine perpetuae tabulae oleagineae ustilatae quam creberrime instruantur, uti utraeque muri frontes inter se, quemadmodum fibulis, his taleis conligatae aeternam habeant firmitatem; namque ei materiae nec caries ¹ nec tempestates ² nec vetustas potest nocere, sed ea et in terra obruta et in aqua conlocata permanent ³ sine vitiiis utilis sempiterno. Itaque non solum in muro sed etiam in substructionibus quique parietes murali crassitudine erunt faciendi, hac ratione rel-
 4 gati non cito vitiabuntur. Intervalla autem turrium ita sunt facienda, ut ne longius sit alia ab alia sagittae missionis,⁴ uti, si qua oppugnetur, tum a turribus, quae erunt dextra sinistra, scorpionibus reliquisque telorum missionibus hostes reiciantur. Etiamque contra inferiores turrium dividendus est murus intervallis tam magnis, quam erunt turres, ut itinera sint interioribus partibus turrium contignata, neque ea ferro fixa. Hostis enim si quam partem muri occupaverit, qui repugnabunt rescindent et, si celeriter administraverint, non patientur reliquas partes tur-

¹ nec aries *a. c. G*, necessities *a. c. H*. ² tempestas *G*.

³ permanet *G*: permanent *H*. ⁴ sagitta emissionis *H*.

¹ Vitruvius follows the general traditions of Roman fortification. He is especially confirmed by the walls of Pompeii.

BOOK I. c. v.

of the wall. For when it is so done, then as the troops approach, their right side will be next the wall and will not be protected by the shield. Moreover, towns are not to be planned square¹ nor with projecting angles, but on the round, so that the enemy be seen from several sides. For when angles run out, defence is difficult, because the angle defends the enemy rather than the townsmen. 3. But I think the width of the wall should be so made that armed men meeting one another above can pass without hindrance. Then, in the width, through-timbers of charred olive wood should be put very frequently, in order that both fronts of the wall, being tied together by these timbers, as though by pins, may have everlasting strength. For such timber cannot be injured by decay or weather or age; even when it is covered with soil or placed in water, it remains unimpaired and useful for ever. And so not only the city wall, but the substructures, and those dividing walls which are made to be of the thickness of fortifications, when united in this manner, will not quickly be decayed. 4. The distances between the towers are so to be made that one is not further from another than a bowshot; so that if a tower is besieged anywhere, then, by "scorpions" and other missile engines from the towers right and left, the enemy may be thrown back. And also opposite the lower part of the towers, the wall is to be divided by intervals as wide as a tower; and these intervals opposite the interior parts of the towers shall be joined with planks. These, however, are not to be fixed with iron nails. For if the enemy occupies any part of the wall, the defenders shall cut them down, and if they manage it quickly, they will

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rium murique hostem penetrare, nisi se voluerit
 5 praecipitare. Turres itaque rutundae¹ aut poly-
 goneae² sunt faciendae; quadratas enim machinae
 celerius dissipant, quod angulos arietes tundendo
 frangunt, in rotundationibus autem, uti cuneus,³ ad
 centrum adigendo laedere non possunt. Item muni-
 tiones muri turriumque aggeribus coniunctae maxime
 sunt tutiores, quod neque arietes neque suffossiones
 6 neque machinae ceterae eis valent nocere. Sed non
 in omnibus locis est aggeris ratio facienda, nisi quibus
 extra murum ex alto loco plano pede accessus fuerit
 ad moenia⁴ oppugnanda. Itaque in eiusmodi locis
 primum fossae sunt faciendae latitudinibus et alti-
 tudinibus quam amplissimis, deinde fundamentum
 muri deprimendum est intra alveum fossae et id ex-
 truendum est ea crassitudine, ut opus terrenum facile
 7 sustineatur. Item interiore parte substructionis
 fundamentum distans ab exteriori introrsus amplo
 spatio, ita uti cohortes possint quemadmodum in acie
 instructae ad defendendum supra latitudinem aggeris
 consistere. Cum autem fundamenta ita distantia
 inter se fuerint constituta, tunc inter ea alia trans-
 versa, coniuncta exteriori et interiori fundamento,
 pectinatim disposita quemadmodum serrae dentes
 solent⁵ esse conlocentur; cum enim sic erit factum,
 tunc ita oneris terreni magnitudo distributa in parvas
 partes; neque universa pondere⁶ premens poterit
 8 ulla ratione extrudere muri substructiones. De ipso

¹ rutundae *a. c. H.*

³ cuneus *H.*

⁵ solentes se *G.*, solventes se *H.*

² polygonea *HG.*

⁴ munia *H.*

⁶ pondera *G.*

BOOK I. c. v.

not suffer the enemy to penetrate the rest of the towers and wall, unless he is willing to throw himself headlong. 5. The towers therefore are to be made round or polygonal. For engines more quickly demolish square towers, because the battering-rams beat and break the angles; whereas in the case of rounded surfaces, even when they drive the battering-rams wedge-fashion towards the centre, they cannot hurt them. Further, the fortifications of the wall and towers especially when joined by embankments are safer, because neither battering-rams nor undermining nor other contrivances avail to injure them. 6. But not in all places is the method of embankment to be employed; only where there is an approach outside the wall from high ground by a level footway for troops besieging the ramparts. Therefore in places of this kind, ditches are to be made of the amplest possible breadth and depth; then the foundation of the wall is to be carried down within the hollow of the ditch, and is to be constructed of such a thickness that the weight of earth is easily held up. 7. Also on the inner side of the substructure another foundation is to be laid, so far distant from the outer foundation that cohorts can stand upon the broad rampart for its defence, as when drawn up in line of battle. Now when the foundations are fixed at such a distance from each other, then between these let there be placed other transverse walls joined to the outer and inner foundation, arranged comb-fashion, as the teeth of a saw are wont to be. For when it shall so be done, then the greatness of the load of earth being thus distributed into small parts, will not press with the whole weight, so as to thrust out the substructures of the wall.

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autem muro, e qua materia struatur aut perficiatur, ideo non est praefiniendum, quod in omnibus locis, quas optamus copias, eas non possumus habere. Sed ubi sunt saxa quadrata sive silex seu caementum aut coctus later sive crudus, his erit utendum. Non enim, uti Babylone abundantes liquido bitumine pro calce et harena ex¹ cocto latere factum habent murum, sic item possunt omnes regiones seu locorum proprietates habere tantas eiusdem generis utilitatis,² uti ex his comparationibus ad aeternitatem perfectus habeatur sine vitio murus.

VI

- 1 MOENIBUS circumdatis secuntur³ intra murum earum divisiones platearumque et angiportuum ad caeli regionem directiones. Dirigentur haec autem recte, si exclusi erunt ex angiportis venti prudenter. Qui si frigidi sunt, laedunt; si calidi, vitiant; si umidi, nocent. Quare vitandum videtur hoc vitium et avertendum, ne fiat quod in multis civitatibus usu solet venire. Quemadmodum in insula Lesbo oppidum Mytilenae magnificenter est aedificatum et eleganter, sed positum non prudenter. In qua civi-

¹ ex *Ro*: et(&) *H*.

² utilitatis *H*.

³ secuntur *H*.

¹ Vitruvius probably draws upon Herodotus, Book I.

² Town-planning was especially studied by the Greek architects. Hippodamus of Miletus laid out the Piraeus, the port of Athens, and in 443 B.C. Thurii. Dinocrates laid out Alexandria. These cities had square blocks with wide streets.

BOOK I. c. v.—c. vi.

8. Respecting the wall itself and the material of which it is built or finished, there must be laid down no rule beforehand; because we cannot have in all places the supplies which we desire. But where there are squared stones, or concrete or lava or baked brick or unburnt, we must use them. For whereas at Babylon,¹ where they have plenty of liquid pitch instead of lime and sand, they can have their walls built of burnt brick; other regions or useful sites have their special advantages, so that with due preparation a wall can be built perfect for ever and unblemished.

CHAPTER VI

RESPECTING THE DIVISION OF THE WORKS WHICH ARE
INSIDE THE WALLS AND THEIR ARRANGEMENT SO
THAT THE NOXIOUS BREATH OF THE WINDS MAY
BE AVOIDED

1. WHEN the walls are set round the city, there follow the divisions of the sites ² within the walls, and the layings out of the broad streets and the alleys with a view to aspect. These will be rightly laid out if the winds are carefully shut out from the alleys. For if the winds are cold they are unpleasant; if hot, they infect; if moist, they are injurious. Wherefore this fault must be avoided and guarded against, lest there happen what in many cities is not infrequent. For example in the island of Lesbos, the town of Mytilene is magnificently and elegantly built, but not situated with prudence. For in this city when the South wind

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tate auster cum flat, homines aegrotant; cum corus, tussunt; cum septentrio, restituuntur in salubritatem, sed in angiportis et plateis non possunt consistere propter vehementiam frigoris. Ventus autem est aeris fluens unda cum incerta motus redundantia. Nascitur cum fervor offendit umorem et impetus factionis exprimit vim spiritus flatus. Id autem verum esse ex aeolis¹ aereis² licet aspicere et de latentibus caeli rationibus artificiosis rerum inventionibus divinitatis exprimere veritatem. Fiunt enim aeoli pilae³ aereae cavae,—hae habent punctum angustissimum—quae aqua⁴ infunduntur conlocanturque ad ignem; et antequam calescant, non habent ullum spiritum, simul autem ut fervere coeperint, efficiunt ad ignem vehementem⁵ flatum. Ita scire et iudicare licet e parvo brevissimoque spectaculo de magnis et inmanibus caeli ventorumque naturae rationibus. Exclusi fuerint; non solum efficient corporibus valentibus locum salubrem, sed etiam si qui morbi ex aliis vitiis forte nascentur, qui in ceteris salubribus locis habent curationes medicinae contrariae, in his propter exclusiones ventorum temperatura⁶ expeditius curabuntur. Vitia autem sunt, quae difficulter curantur in regionibus, quae sunt supra scriptae, haec: gravitudo arteriace, tussis, pleuritis, pthisis, sanguinis eiectio et cetera, quae non detractationibus sed adiectionibus curantur. Haec ideo difficulter medicantur, primum quod ex frigoribus concipiuntur,

¹ aeolis *H.*

² aeris *H.*

³ aeolipilae *H.*

⁴ quae aqua *GS*: quae qua *H.*

⁵ vehementum *H.*

⁶ exclusiones v. temperatura *Kr*: temperatura (-am) exclusiones v. *H.*

¹ This experiment anticipated Watt and the kettle, but led to no practical consequences. The figure must have had a small opening at the top only.

BOOK I. c. vi.

blows men fall ill; when the North-west, they cough; when the North, they are restored to health; but they cannot stand in the alleys and streets because of the vehemence of the cold. 2. Now the wind is a wave of air flowing with uncertain currents of motion. It rises when heat strikes moisture and the onrush of the force presses out the power of the breath of the blast. That this is true we may see from Aeoluses of bronze,¹ and by the craftsman's inventions of things which express the truth of the divinity, about the causes which lurk in the heavens. Now figures of Aeolus are made of hollow bronze, and they have a very narrow point. These are filled with water and placed on the fire; before they begin to warm, they have no rush of air, but as soon as they begin to boil, they produce on the fire a vehement blast. Thus we may know and judge, from this small and very brief spectacle, about the great and immense causes of the nature of the sky and of the winds. 3. Suppose they are excluded. Not only will this render a place healthy for sound persons; but also if any diseases shall happen to arise from other infections, those who in other healthy places find cure from counteracting medicine, in these, on account of the moderate climate and by the exclusion of the winds, will be still more quickly cured. For the diseases which are cured with difficulty in the regions which are described above are these: cold in the windpipe, cough, pleurisy, phthisis, spitting of blood, and others which are cured by strengthening remedies rather than by purgings. These ailments are treated with difficulty, first because they are caught from chills, secondly because

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deinde quod defatigatis morbo viribus eorum aer agitated est, ventorum agitationibus extenuatur,¹ unaque a vitiosis corporibus detrahit sucum et efficit ea exiliora. Contra vero lenis et crassus aer qui perflatus non habet neque crebras redundantias, propter inmotam stabilitatem adiciendo ad membra eorum alit eos et reficit, qui in his sunt impliciti morbis.

- 4 Nonnullis placuit esse ventos² quattuor: ab oriente aequinoctiali solanum, a meridie austrum, ab occidente aequinoctiali favonium, ab septentrionali septentrionem. Sed qui diligentius perquisierunt, tradiderunt eos esse octo, maxime quidem Andronicus Cyrrestes, qui etiam exemplum conlocavit Athenis turrem marmoream octagonon et in singulis lateribus octagoni singulorum ventorum imagines exscalptas³ contra suos cuiusque flatus designavit, supraque eam turrim metam marmoream perfecit et insuper Tritonem aereum conlocavit dextra manu virgam porrigentem, et ita est machinatus, uti vento circumageretur et semper contra flatum consisteret supraque imaginem flantis venti indicem virgam teneret.
- 5 Itaque sunt conlocati inter solanum et austrum ab oriente hiberno eurus, inter austrum et favonium ab occidente hiberno africanus, inter favonium et septentrionem caurus, quem plures vocant corum, inter septentrionem et solanum aquilo. Hoc modo videtur esse expressum, uti capiat numerus et nomina et

¹ extenuatur *Joc*: extenuabitur unaque *H*.

² ventus *H*.

³ exscalptas *G*, exscalpas *H*.

¹ Usually called *subsolanus*: *salubriores septentrionales quam subsolani vel austri sunt*. Cels. ii. 1.

² Caused storms in the Adriatic. Horace, *Odes*, III. iii. 4-5.

³ Brought the spring. Horace, *Odes*, I. iv. 1.

BOOK I. c. vi.

when the strength is worn out by disease the air is agitated; it is thinned by the agitation of the winds; at the same time it draws the sap from diseased persons and renders them thinner. On the other hand, a smooth and thick air which is free from the passage of draughts and does not move backwards and forwards, builds up their limbs by its steadiness, and so nourishes and refreshes those who are caught by these diseases.

4. Some have held that there are four winds: the Solanus¹ from the equinoctial east, the Auster² from the south, Favonius³ from the equinoctial west, and Septentrio from the north. But those who have inquired more diligently lay down that there are eight: especially indeed Andronicus of Cyrrha,⁴ who also, for an example, built at Athens⁵ an octagonal marble tower, and, on the several sides of the octagon, had representations of the winds carved opposite their several currents. And above that tower he caused to be made a marble upright, and above it he placed a bronze Triton holding a rod in his right hand. He so contrived that it was driven round by the wind, and always faced the current of air, and held the rod as indicator above the representation of the wind blowing. 5. Therefore there are placed between the Solanus and the Auster, the Eurys from the winter sunrising; between the Auster and the Favonius, the Africus from the winter sunset; between the Favonius and the Septentrio, the Caurus (which most people call Corus); between the Septentrio and the Solanus, the Aquilo. The diagram⁶ seems to be so arranged as to receive the

¹ A town in Syria.

² The Tower of the Winds: first century B.C.

³ See figure.

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partes, unde flatus certi ventorum spirent. Quod cum ita exploratum habeatur, ut inveniantur regiones 6 et ortus eorum, sic erit ratiocinandum. Conlocetur ad libellam ¹ marmoreum amusium ² mediis moenibus, aut locus ita expoliatur ad regulam et libellam, ut amusium non desideretur, supraque eius loci centrum medium conlocetur aeneus ³ gnomon, indagator umbrae qui graece *sciotheres* dicitur. Huius antemeridiana hora circiter hora quinta sumenda est extrema gnomonis ⁴ umbra et puncto signanda, deinde circino diducto ad punctum, quod est gnomonis umbrae longitudinis signum, ex eoque a centro circumagenda linea rotundationis. Itemque observanda postmeridiana istius gnomonis crescens umbra, et cum tetigerit circinationis lineam et fecerit parem antemeridianae umbrae postmeridianam, signanda 7 puncto. Ex his duobus signis circino decusatim describendum, et per decusationem et medium centrum linea perducenda ad extremum, ut habeatur meridiana et septentrionalis ⁵ regio. Tum postea sumenda est sexta decima pars circinationis lineae totius rotundationis, centrumque conlocandum in meridiana linea, qua ⁶ tangit circinationem, et signandum dextra ac sinistra in circinatione et meridiana et septentrionali parte. Tunc ex signis his quattuor per centrum medium decusatim lineae ab extremis ad extremas circinationes perducendae. Ita austri et septentrionis habebitur octavae partis designatio.

¹ libellum *H.*

² hamusium *G.*

³ aeneos *H.*

⁴ gnomonis *H.*

⁵ septentrionales *H.*

⁶ qua *Phil.*: quae *H.*

¹ Invented by Anaximander. Dio, L. II. See Plate A.

² Carelessly expressed; Vitruvius means the chord of the arc which is $\frac{1}{8}$ of circumference.

BOOK I. c. vi.

names and the quarters whence the fixed currents of winds blow. Since these may be regarded as ascertained, we must calculate as follows to find the quarters and risings of the winds. 6. Let there be placed to a level a marble dial, somewhere in the middle of the city; or let a space be so polished to rule and level that the marble dial is not wanted. Above the middle point of that place, let there be put a bronze indicator to track the shadow¹ (which in Greek is called *sciotheres*). Before midday, at about the fifth hour, the end of the shadow of the indicator is to be taken and marked with a point. Then a radius being taken from the indicator to the point which marks the length of the shadow, with that, from the indicator as centre, a circumference is to be drawn. After midday the growing shadow of the indicator, when it touches the line of the circle and marks a post-meridian shadow equal to the ante-meridian, is to be marked with a point. 7. From these two points, two intersecting circles are to be described. Through the intersection and the centre of the circle first described, a line is to be carried through to the end so that the southern and northern quarters may be indicated. Next we take as radius the sixteenth part² of the circumference of the circle. From centres given by the meridian line at the two points where it touches the circle, and with that radius, points are to be marked right and left in the circle, both on the southern and on the northern part. Then from these four points, intersecting lines are to be drawn through the middle centre from one side of the circumference to the other. Thus both for the south wind and for the north wind we shall have marked out the eighth part of the circumference.

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- Reliquae partes dextra ac sinistra tres, aequales et tres his distribuendae sunt in tota rotundatione, ut aequales divisiones octo ventorum designatae sint in descriptione. Tum per angulos inter duas ventorum regiones et platearum et angiportorum videntur de-
 8 beri¹ dirigi descriptiones. His enim rationibus et ea divisione exclusa erit² ex habitationibus et vicis ventorum vis molesta.³ Cum enim plateae contra directos⁴ ventos⁵ erunt conformatae, ex aperto caeli spatio impetus ac flatus frequens conclusus in faucibus angiportorum vehementioribus viribus pervagabitur. Quas ob res convertendae sunt ab regionibus ventorum derectiones vicorum, uti advenientes ad angulos insularum frangantur repulsique dissipentur.
- 9 Fortasse mirabuntur i qui multa ventorum nomina noverunt, quod a nobis expositi sunt tantum octo esse ventis. Si autem animadverterint orbis terrae circuiti-
 onem per solis cursum et umbras gnomonis⁶ aequinoctialis ex⁷ inclinatione caeli ab Eratosthene Cyrenaeo rationibus mathematicis et geometricis methodis esse inventam ducentorum quinquaginta duum milium stadium, quae fiunt passus trecenties et decies quinquies⁸ centena milia, huius autem octava pars quam ventus tenere videtur, est triciens nongenta triginta septem milia et passus quingenti, non debebunt mirari, si in tam magno spatio unus ventus vagando inclinationibus et recessionibus varie-
 10 tates mutatione flatus faciat. Itaque dextra et sinis-

¹ debere *G.*

² excluserit *H.*

³ molesta vis *G.*

⁴ directos *H*: minus recte directos *rec.*

⁵ ventus *H.*

⁶ gnominis *H.*

⁷ ex *Joc*: et(&) *H.*

⁸ quinquies centena *Kr*: quinquaginta *H.*

BOOK I. c. vi.

The remaining parts in the whole round, three on the right and three on the left, are to be distributed equally, so that equal divisions of the eight winds are marked out in the figure. Then the angles between two quarters of the winds will determine the laying out both of the streets and of the alleys. 8. For by these methods and this division, troublesome winds will be excluded from the dwellings and the streets. For when the quarters of the city are planned to meet the winds full, the rush of air and the frequent breezes from the open space of the sky will move with mightier power, confined as they are in the jaws of the alleys. Wherefore the directions of the streets are to avoid the quarters of the winds, so that when the winds come up against the corners of the blocks of buildings they may be broken, driven back and dissipated.

9. Perhaps those who know many names of the winds will wonder because only eight winds have been described by us to exist. But if they perceive that the circumference of the world, ascertained by the sun's course, and the equinoctial shadows of the gnomon and the inclinations of the sky, have been found by Eratosthenes¹ of Cyrene with mathematical calculations and geometric methods to be 252,000 stades, which give 31,500,000 paces, while of this the eighth part which the wind seems to occupy is 3,937,500 paces, they ought not to wonder, if in so great a space one wind, as it moves with its inclinations and retreats, causes varieties through the change of its current. 10. Therefore on the right

¹ His calculations are remarkably correct in view of his imperfect equipment.

tra austrum leuconotus et altanus flare solet, africanum libonotus et subvesperus, circa favonium argestes et certis temporibus etesiae, ad latera cauri circias¹ et corus, circa septentrionem thracias et gallicus, dextra ac sinistra aquilonem supernas et caecias, circa solanum carbas et certo tempore ornithiae, euri vero medias partes tenentis² in extremis euricircias et voltornus.³ Sunt autem et alia plura nomina flatuque ventorum e locis aut fluminibus aut montium
 11 procellis tracta. Praeterea aurae matutinae, quae⁴ sol, cum emergit de subterranea parte, versando pulsatur aeris umorem et impetu scandendo prudens⁵ exprimit aurarum antelucano spiritu flatu. Qui cum exorto sole permanserunt, euri venti tenent partes, et ea re, quod ex auris procreatur, ab Graecis *euros* videtur esse appellatus, crastinusque dies propter auras matutinas *aurion* fertur esse vocitatus. Sunt autem nonnulli qui negant Eratosthenem potuisse veram mensuram orbis terrae colligere. Quae sive est certa sive non vera, non potest nostra scriptura non veras habere terminationes regionum, unde
 12 spiritus ventorum oriuntur. Ergo si ita est, tantum erit, uti non certam mensurae rationem sed aut maiores impetus aut minores habeant singuli venti.

Quoniam haec a nobis sunt breviter exposita, ut facilius intellegatur, visum est mihi in extremo volumine formas⁶ sive uti Graeci *schemata* dicunt, duo

¹ circias *H.*

² tenentis *Joc*: -tes *H.*

³ vultornus *G.*

⁴ quae *Ro*: quas *H.*

⁵ prudens *HG*, procedens *S.*

⁶ formas *Phil*: formā *H.*

¹ At Dougga in Tunis, adjoining the Capitol, is a dial of the winds more than 8 yards in diameter. Twelve winds are marked closely agreeing with Vitruvius. One of them is *Euroaquilo*; the same as *Euracylo*, *Acts* xxvii. 14.

BOOK I. c. vi.

and left of Auster,¹ Leuconotus and Altanus are wont to blow; of Africus, Libonotus and Subvesperus; around Favonius, Argestes and at certain times the Etesian winds²; at the sides of Caurus, Circias and Corus; about Septentrio, Thracias and Gallicus; right and left of Aquilo, Supernas and Caecias; around Solanus, Carbas and at a definite time Ornithiae; on the distant parts, when Eurus holds the middle, Euricircias and Volturnus. There are also many other names and breezes of winds, drawn from places, or rivers, or from mountain storms.

11. Moreover there are morning airs, when the sun, emerging from the subterranean part, tosses and beats the damp in the air, and rising with a rush looks forward and thrusts forth the breezes with the breath that comes before the light. And when these have remained after sunrise, they hold the region of the east wind. Because this is generated from *aurae* (breezes) it seems to be called *euros* by the Greeks, and because of morning breezes the morrow is said to have been called *aurion*. But there are some who deny that Eratosthenes could infer the true measure of the earth. Whether this is certain or not, our writing cannot fail to furnish true outlines of the regions whence arise the breezes of the winds.

12. Therefore if it is so, it will have this consequence, that the several winds will have, not a fixed and measured amount, but either greater or less impetus.

Since these matters have been briefly set forth by us, in order that it may be more easily understood I have decided at the end of the book to furnish two plans, or as the Greeks say *schemata*: one³ so

² Lucr. V. 742: *etesia flabra àquilonum*.

³ Plate A, fig. 1.

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- explicare, unum ita deformatum, ut appareat, unde certi ventorum spiritus oriantur, alterum, quemadmodum ab impetu eorum aversis derectionibus vicorum et platearum evitentur nocentes flatus. Erit autem in exaequata planitie centrum, ubi est littera A, gnomonis autem antemeridiana umbra, ubi est B, et a centro, ubi est A, diducto circino ad id signum umbrae, ubi est B, circumagatur linea rotundationis. Reposito autem gnomone ubi antea fuerat, expectanda est, dum decrescat faciatque iterum crescendo parem ¹ antemeridianae umbrae postmeridianam tangatque lineam rotundationis, ubi erit littera C. Tunc a signo, ubi est B, et a signo, ubi est C, circino decusatim describatur, ubi erit D; deinde per decusationem et centrum, ubi est D, perducatur linea ad ² extremum, in qua linea erit ³ littera E et F. Haec linea erit index meridianae et septentrionalis ⁴ regionis.
- 13 Tunc circino totius rotundationis sumenda est pars XVI, circinique centrum ponendum est in meridiana linea, qua ⁵ tangit rotundationem, ubi est littera E, et signandum dextra sinistra, ubi erunt litterae G H. Item in septentrionali parte centrum circini ponendum in rotundationis et septentrionali linea, ubi est littera F, et signandum dextra ac sinistra, ubi sunt litterae I et K, et ab G ad K et ab H ad I per centrum lineae perducendae. Ita quod erit spatium ab G ad H, erit spatium venti austri et partis meridianae: item quod erit spatium ab I ad K, erit septentrionis. Reliquae partes dextra tres ⁶ ac sinistra tres dividendae sunt aequaliter, quae sunt ad orientem, in quibus litterae

¹ parem G: partem H. ² ad S: ab HG.

³ erunt litterae S: erit littera HG.

⁴ septentrionales H. ⁵ qua Gal: quae H.

⁶ dextra tres ac sinistra tres H.

BOOK I. c. vi.

mapped out that it may appear whence the certain breezes of the winds arise; the second,¹ how by layings out of quarters and streets turned away from their violence, dangerous currents may be avoided. Now there shall be on a levelled surface a centre with the letter A; the shadow before midday of the indicator, with B; and from the centre marked A the compass is opened to the point of shadow marked B, and a circle is to be drawn. The indicator being replaced where it was before, we must wait until the shadow diminishes, and again by increasing makes the shadow after midday equal to that before midday and touches the circle at the letter C. Then from B and from C let the intersection D be described with the compasses; then through the intersection D and the centre, let a line be carried through to the furthest limit, where will be the letter E and also F, and on this line will be the index of the southern and northern regions. 13. Then the sixteenth part of the whole circle is to be taken with the compass, and the point of the compass is to be put on the meridian line where it touches the circumference at E, and a mark is to be made right and left at GH. Also in the northern part, the point of the compass is to be placed on the circumference and the northern line where is the letter F, and a mark is to be made right and left at I and K. And from G and K and from H to I, lines are to be drawn through the centre. So the space from G to H will be the space of the Auster and of the southern region; likewise the space from I to K will be of the Septentrio. The remaining parts, on the right three, and the left three, are to be divided equally; those which are to

¹ Plate A, fig. 2. Vitruvius had probably experienced the Mistral at Marseilles.

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L M, et ab occidente, in quibus sunt litterae N et O. Ab M ad O et ab L ad N perducendae sunt lineae decussatim. Et ita erunt aequaliter ventorum octo spatia in circumitionem.¹ Quae cum ita descripta erunt, in singulis angulis octagoni, cum a meridie incipiemus, inter eorum et austrum in angulo erit littera G, inter austrum et africanum H, inter africanum et favonium N, inter favonium et caurum O, inter caurum et septentrionem K, inter septentrionem et aquilonem I, inter aquilonem et solanum L, inter solanum et eorum M. Ita his confectis inter angulos octagoni gnomon ponatur, et ita dirigantur angiportorum divisiones.

VII

- 1 Divisis angiportis et plateis constitutis arearum electio ad opportunitatem et usum communem civitatis est explicanda aedibus sacris, foro reliquisque locis communibus. Et si erunt moenia secundum mare, area ubi forum constituatur, eligenda proxime portum, sin autem mediterraneo, in oppido medio. Aedibus vero sacris, quorum deorum maxime in tutela civitas videtur esse, et Iovi et Iunoni et Minervae, in excelsissimo loco unde moenium maxima pars conspiciatur, areae distribuuntur. Mercurio

¹ circumitione G, -nem H.

¹ As at Halicarnassus. Book II. viii. 11.

² As at Athens, Pompeii, Timgad and other Roman towns in North Africa.

³ There were three shrines side by side; Jupiter in the middle, Juno on his right, Minerva on his left. The Capitol

BOOK I. c. VI.—c. VII.

the east at L and M, and at the west at N and O. From M to O and from L to N intersecting lines are to be drawn. And so there will be eight equal spaces of winds in the circumference. When these are so marked out, at the single angles of the octagon when we begin from the south, in the angle between Eurus and Auster there will be G, between Auster and Africus there will be H, between Africus and Favonius N, between Favonius and Caurus O, between Caurus and Septentrio K, between Septentrio and Aquilo I, between Aquilo and Solanus L, between Solanus and Eurus M. When these things are done, let the gnomon be set upon the angles of the octagon and let the division of the alleys be directed accordingly.

CHAPTER VII

ON THE SITES OF PUBLIC BUILDINGS

1. AFTER apportioning the alleys and settling the main streets, the choice of sites for the convenience and common use of citizens has to be explained; for sacred buildings, the forum, and the other public places. And if the ramparts are by *the sea*,¹ a site where the forum is to be put is to be chosen next the harbour; but if *inland*,² in the middle of the town. But for sacred buildings of the gods under whose protection the city most seems to be, both for Jupiter and Juno and Minerva,³ the sites are to be distributed on the highest ground from which the most of the ramparts is to be seen. To Mercury,

at Dougga in Tunis is said to follow the rules of Vitruvius, except that the order is Corinthian.

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autem in foro, aut etiam ut Isidi et Serapī in emporio; Apollini Patrique Libero secundum theatrum; Herculi, in quibus civitatibus non sunt gymnasia neque amphitheatra, ad circum: Marti extra urbem sed ad campum; itemque Veneri ad portum.

Id autem etiam Etruscis haruspibus disciplinarum scripturis ita est dedicatum, extra murum Veneris, Volcani, Martis fana ideo conlocari, uti non insuescat ¹ in urbe adulescentibus, seu matribus familiarum veneria libido, Volcanique vi ² e moenibus religionibus et sacrificiis evocata ab ³ timore incendiorum aedificia videantur liberari. Martis vero divinitas cum sit extra moenia dedicata, non erit inter cives armigera dissensio, sed ab hostibus ea defensa ⁴ a ² belli periculo conservabit. Item Cereri ⁵ extra urbem loco, quo nomine semper homines, nisi per sacrificium, necesse habeant adire; cum religione, caste sanctisque moribus is locus debet tueri. Ceterisque diis ad sacrificiorum rationes aptae templis areae sunt distribuendae.

De ipsis autem aedibus sacris faciundis et de arearum symmetriis in tertio et quarto volumine reddam rationes, quia in secundo visum est mihi primum de materiae copiis quae in aedificiis sunt parandae, quibus sint virtutibus et quem habeant usum, exponere, commensus aedificiorum et ordines et genera singula symmetriarum peragere et in singulis voluminibus explicare.

¹ insuescat *S*²: -cant *H*.

² vi *Joc*: vis *H*.

³ a timore *G*.

⁴ defensa *G*²: -si *H*.

⁵ cerei *H*.

¹ At Pompeii adjoins the theatre.

² Outside Porta Capena at Rome, Platner, 327.

³ The scribe of *H* adds: The first book ends, Thank the Lord: Amen.

BOOK I. c. vii.

however, in the forum, or also, as to Isis and Serapis,¹ in the business quarter; to Apollo and Father Bacchus against the theatre; to Hercules, in cities which have no gymnasia nor amphitheatres, at the circus; to Mars outside the walls but in the parade ground; and also to Venus near the harbour.

Now with Etruscan haruspices in the writings of their disciplines, the dedication is as follows: that the shrines of Venus, Volcanus, Mars are therefore to be situated outside the wall, so that venereal pleasure may not be customary to young men and matrons in the city, and, by summoning the power of Volcanus outside the ramparts with ritual and sacrifices, the buildings may seem to be freed from fear of fires. But since the divinity of Mars² is dedicated outside the ramparts, there will not be armed quarrels among citizens, yet he will keep the ramparts defended from the danger of war. 2. So also to Ceres in a place outside the city, under which name (*i.e.* Ceres extra urbem) men (unless by sacrifice) must always approach her; since that place must be kept religiously, purely and with strict manners. And to the other gods sites fit for temples with a view to the methods of sacrifice are to be arranged.

Now about building temples and about symmetrical arrangement of sites I will give an account in the third and fourth books, because in the second I purpose, first, with reference to the supplies of material which are to be prepared in buildings, to set forth of what virtues they are possessed, and what uses they have; subsequently to treat of the dimensions of buildings, the orders and the several kinds of symmetry and to explain them in the several books.³

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BOOK II

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LIBER SECUNDUS

- 1 DINOCRATES architectus cogitationibus et sollertia fretus, cum Alexander rerum potiretur, profectus est e Macedonia¹ ad exercitum regiae cupidus commendationis. Is e patria a propinquis et amicis tulit ad primos ordines et purpuratos litteras, aditus haberet faciliores, ab eisque exceptus humane petit, uti quamprimum ad Alexandrum perduceretur. Cum polliciti essent, tardiores fuerunt idoneum tempus expectantes. Itaque Dinocrates ab his se existimans² ludi ab se petit praesidium. Fuerat enim amplissima statura, facie grata, forma dignitateque summa. His igitur naturae muneribus confisus vestimenta posuit in hospitio et oleo corpus perunxit caputque coronavit populea fronde, laevum umerum pelle leonina texit, dextraque clavam tenens incessit contra tribunal
- 2 regis ius dicentis. Novitas populum cum avertisset, conspexit eum Alexander. Admirans ei iussit³ locum dari, ut accederet, interrogavitque, quis esset. At ille: "Dinocrates," inquit, "architectus Macedo qui ad te cogitationes et formas adfero dignas tuae claritati. Namque Athon montem formavi in statuae virilis figuram, cuius manu laeva designavi civitatis amplissimae moenia, dextera⁴ pateram, quae exciperet omnium fluminum, quae sunt in eo monte,

¹ e (macedonia) *H*: a m. *G*.

² exestimans *H*.

³ ei iussit *H*: iussit ei *G*.

⁴ dextra *G*.

¹ Dinocrates was also architect of the new temple of Diana (Artemis) at Ephesus to replace the one burnt down.

² He seems, by his club and lion's skin, to have personified Hercules (Herakles).

BOOK II

PREFACE

1. WHEN Alexander was master of the world, the architect Dinocrates,¹ confident in his ideas and his skill, set out from Macedonia to the army, being desirous of the royal commendation. He brought from home to the officers and high officials, a letter from his relatives and friends that he might have more easy access; and being courteously received by them, he asked to be introduced as soon as possible to Alexander. After promising this they were somewhat slow, waiting for a suitable occasion. Therefore Dinocrates, thinking he was mocked by them, sought a remedy from himself. Now he was of ample stature, pleasing countenance, and the highest grace and dignity. Trusting then in these gifts of nature, he left his clothes in the inn, and anointed himself with oil; he wreathed his head with poplar leaves, covered his left shoulder with a lion's skin, and holding a club in his right hand,² he walked opposite the tribunal where the king was giving judgment.

2. When this novel spectacle attracted the people, Alexander saw him. Wondering, he commanded room to be made for him to approach, and asked who he was. And he replied: "Dinocrates, a Macedonian architect, who brings you ideas and plans worthy of you, illustrious prince. For I have shaped Mount Athos into the figure of the statue of a man, in whose left hand I have shown the ramparts of a very extensive city; in his right a bowl to receive the water of all

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3 aquam, ut inde in mare profunderetur." Delectatus Alexander natione ¹ formae statim quaesivit, si essent agri circa, qui possint ² frumentaria ratione eam civitatem tueri. Cum invenisset non posse nisi transmarinis subvectionibus: "Dinocrates," inquit, "adtendo egregiam formae compositionem et ea delector. Sed animadverto, si qui deduxerit ³ eo loco coloniam, forte ⁴ ut iudicium eius vituperetur. Ut enim natus infans sine nutricis lacte non potest ali neque ad vitae crescentis gradus perducere, sic civitas sine agris et eorum fructibus in moenibus affluentibus non potest crescere nec sine abundantia cibi frequentiam habere populumque sine copia tueri. Itaque quemadmodum formationem puto probandam, sic iudicio locum inprobandum; teque volo esse
4 mecum, quod tua opera sum usus." Ex eo Dinocrates ab rege non discessit et in Aegyptum est eum persecutus. Ibi Alexander cum animadvertisset portum naturaliter tutum, emporium egregium, campos circa totam Aegyptum frumentarios, inmanis fluminis Nili magnas utilitates, iussit eum suo nomine civitatem Alexandriam constituere. Ita Dinocrates a facie dignitateque ⁵ corporis commendatus ad eam nobilitatem pervenit. Mihi autem, imperator, staturam non tribuit natura, faciem deformavit aetas, valetudo detraxit vires. Itaque quoniam ab his praesidiis sum desertus, per auxilia ⁶ scientiae scriptaque, ut spero, perveniam ad commendationem.

¹ ratione *G*: natione *H*, sc. genere, cf. *Plin. N.H.*

² possent *G*: possint *H*.

³ siquid eduxerit *H*. loci *Phil*: loco *H*.

⁴ fore *G*²: forte *H*. ⁵ dignitatisque *H*.

⁶ auxilia *H*: auxilium *G*.

¹ Alexandria was laid out in streets at right angles to one another. There were two main streets, one the famous

BOOK II. PREFACE

the rivers which are in that mountain." 3. Alexander, delighted with his kind of plan, at once inquired if there were fields about, which could furnish that city with a corn supply. When he found this could not be done, except by sea transport, he said: "I note, Dinocrates, the unusual formation of your plan, and am pleased with it, but I perceive that if anyone leads a colony to that place, his judgment will be blamed. For just as a child when born, if it lacks the nurse's milk cannot be fed, nor led up the staircase of growing life, so a city without cornfields and their produce abounding within its ramparts, cannot grow, nor become populous without abundance of food, nor maintain its people without a supply. Therefore, just as I think your *planning* worthy of approval, so, in my judgment, the *site* is worthy of disapproval; yet I want you to be with me, because I intend to make use of your services." 4. After that, Dinocrates did not leave the king, and followed him into Egypt. There when Alexander had observed a port naturally protected, an excellent market, cornfields all over Egypt, the great advantages of the huge Nile river, he ordered Dinocrates to lay out a city in his name, Alexandria.¹ Thus, Dinocrates, commended by his face and the dignity of his person, reached to this distinction. But nature has not given me stature, my countenance is uncomely with age, ill-health has taken away my strength. Therefore, although I am deserted by these defences, by the help of science and by my writings I shall, I hope, gain approval.

Canopic Street running east and west. These were 46 feet wide, bordered with columns. The others mostly 23 feet. The chief temple—the Serapeum—corresponding to the Roman Capitol, was on rising ground. The splendid banqueting hall of Ptolemy Philadelphus is described in Athenaeus, p. 196.

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5 Cum autem primo volumine de officio architecturae terminationibusque artis perscripsi, item de moenibus et intra moenia arearum divisionibus, insequatur ordo de aedibus sacris et publicis aedificiis itemque privatis, quibus proportionibus et symmetriis debeant esse, uti explicentur, non putavi ante ponendum, nisi prius de materiae copiis, e quibus conlatis aedificia structuris et materiae rationibus perficiuntur, quas habeant in usu virtutes, exposuissem, quibusque rerum naturae principiis essent temperata, dixissem. Sed antequam naturales res incipiam explicare, de aedificiorum rationibus, unde initia ceperint¹ et uti creverint eorum inventiones, ante ponam, et insequar ingressus antiquitatis rerum naturae et eorum qui initia humanitatis² et inventiones perquisitas scriptorum praeceptis dedicaverunt. Itaque quemadmodum ab his sum institutus, exponam.

I

1 HOMINES vetere more ut ferae in silvis et speluncis et nemoribus nascebantur ciboque agresti vescendo vitam exigebant. Interea quondam in loco ab³ tempestatibus et ventis densae crebritatibus arbores agitatae et inter se terentes ramos ignem excita-verunt, et eius⁴ flamma vehementi perterriti, qui circa

¹ coeperint *H.*

² humanitates *H.*

³ a temp. *G.*

⁴ eius *Sch* : eos *H.*

BOOK II. C. I.

5. Now since in the first book I have written on the services of architecture, and the definitions of the craft, also about ramparts and the allotments of sites within the ramparts, there should follow the arranging of temples and public buildings and also private ones, in order to explain of what proportions and symmetries they ought to be. Yet I thought I ought to put nothing before, until I had first considered the supplies of building material, from the assemblage of which buildings are completed in their structure and the appropriate treatment of the materials. Afterwards I shall expound what virtues they have when employed, and I shall declare of what natural elements they are blended. But before I begin to explain natural objects, I will preface somewhat respecting the methods of building, whence they took their beginnings and how inventions grew; and I will follow the approaches of antiquity to Nature herself, and in particular of those writers who have committed to their manuals the beginnings of the humanities, and the record of inventions. Therefore I will set forth the matter as I have been instructed by them.

CHAPTER I

THE ORIGIN OF BUILDING

1. MEN, in the old way, were born like animals in forests and caves and woods, and passed their life feeding on the food of the fields. Meanwhile, once upon a time, in a certain place, trees, thickly crowded, tossed by storms and winds and rubbing their branches together, kindled a fire. Terrified by the raging flame, those who were about that place were put to

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eum locum fuerunt, sunt fugati. Postea re quieta¹ propius² accedentes cum animadvertissent commoditatem esse magnam corporibus ad ignis teporem, ligna adicientes et id conservantes alios adducebant et nutu monstrantes ostendebant, quas haberent ex eo utilitates. In eo hominum congressu cum profundebantur aliter e spiritu voces, cotidiana consuetudine vocabula, ut optigerant,³ constituerunt, deinde significando res saepius in usu ex eventu fari fortuito coeperunt et ita sermones inter se procreaverunt. Ergo cum propter ignis inventionem conventus initio apud homines et concilium et convictus esset natus, et in unum locum plures convenirent habentes ab natura praemium praeter reliqua animalia, ut non proni sed erecti ambularent mundique et astrorum magnificentiam aspicerent, item manibus et articulis quam vellent rem faciliter tractarent, coeperunt in eo coetu alii de fronde facere tecta, alii speluncas fodere sub montibus, nonnulli hirundinum nidos et aedificationes earum imitantes de luto et virgulis facere loca quae subirent. Tunc observantes aliena tecta et adicientes suis cogitationibus res novas, efficiebant in dies meliora genera casarum. Cum essent autem homines imitabili docilique natura, cotidie inventionibus gloriantes alios alii ostendebant aedificiorum effectus, et ita exercentes ingenia certationibus in

¹ re quieta *S*^c: requieta *H*, requie data *G*.

² propius *H*.

³ obtigerant *S* *G*^c: optegerent *H*.

¹ The invention of language is dealt with by Lucr. V. 1028; of fire, V. 1091. Cf. Darwin, *Descent of Man*, Part I.

² The importance of handiwork and craftsmanship is emphasised throughout this treatise and gives it a unique importance.

BOOK II. c. I.

flight. Afterwards when the thing was quieted down, approaching nearer they perceived that the advantage was great for their bodies from the heat of the fire. They added fuel, and thus keeping it up, they brought others ; and pointing it out by signs they showed what advantages they had from it. In this concourse of mankind, when sounds were variously uttered by the breath, by daily custom they fixed words as they had chanced to come. Then, indicating things more frequently and by habit, they came by chance to speak according to the event, and so they generated conversation with one another.¹ 2. Therefore, because of the discovery of fire, there arose at the beginning, concourse among men, deliberation and a life in common. Many came together into one place, having from nature this boon beyond other animals, that they should walk, not with head down, but upright, and should look upon the magnificence of the world and of the stars. They also easily handled with their hands² and fingers whatever they wished. Hence after thus meeting together, they began, some to make shelters of leaves, some to dig caves under the hills, some to make of mud³ and wattles places for shelter, imitating the nests of swallows and their methods of building. Then observing the houses of others and adding to their ideas new things from day to day, they produced better kinds of huts. 3. Since men were of an imitative and teachable nature, they boasted of their inventions as they daily showed their various achievements in building, and thus, exercising their talents in rivalry, were rendered

³ Wattle-work was used by the Romans in England, following the British precedent.

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dies melioribus iudiciis efficiebantur. Primumque furcis erectis et virgulis interpositis luto parietes texerunt. Alii luteas glaebas arefacientes struebant parietes, materia eos iugumentantes, vitandoque imbres et aestus tegebant harundinibus et fronde. Posteaquam per hibernas tempestates tecta non potuerunt imbres sustinere, fastigia facientes, luto inducto proclinatis tectis, stillicidia deducebant.

- 4 Haec autem ex is, quae suprascripta sunt, originibus instituta esse possumus sic animadvertere, quod ad hunc diem nationibus exteris ex his rebus aedificia constituuntur,¹ uti Gallia, Hispania,² Lusitania, Aquitania scandalis³ robusteis aut stramentis. Apud nationem Colchorum in Ponto propter silvarum abundantiam arboribus perpetuis planis dextra ac sinistra in terra positis, spatio inter eas relicto quanto arborum longitudo patitur, conlocantur in extremis partibus earum supra alterae transversae, quae circumcludunt medium spatium habitationis. Tum⁴ insuper alternis trabibus ex quattuor partibus angulos iugumentantes et ita parietes arboribus statuentes ad perpendicularum imarum educunt ad altitudinem turres, intervallaque, quae relinquuntur propter crassitudinem materiae, schidiis et luto obstruunt. Item tecta, recidentes ad extremos transtra, traiciunt gradatim contrahentes, et ita ex quattuor partibus ad altitudinem educunt medio metas, quas fronde et luto tegentes

¹ constituuntur *G*: antur *H*.

³ scandulis *G*: scandalis *H*.

² spania *HG*.

⁴ tunc *G*.

¹ The name of the neighbouring *Mossynoikoi* means "dwellers in towers" from *mossyn*, a tower. Xenophon, *Anabasis*, V. 4; Ap. Rh. II. 1019.

² The beams run alternately from front to back, and from

BOOK II. c. I.

of better judgment daily. And first, with upright forked props and twigs put between, they wove their walls. Others made walls, drying moistened clods which they bound with wood, and covered with reeds and leafage, so as to escape the rain and heat. When in winter-time the roofs could not withstand the rains, they made ridges, and smearing clay down the sloping roofs, they drew off the rain-water.

4. That these things were so practised from the beginnings above described we can observe, seeing that to this day buildings are constructed for foreign nations of these materials, as in Gaul, Spain, Portugal, Aquitaine, with oak shingles or thatch. In Pontus among the nation of the Colchi,¹ because of their rich forests, two whole trees are laid flat, right and left, on the ground, a space being left between them as wide as the lengths of the trees allow. On the furthest parts of them, two others are placed transversely, and these four trees enclose in the middle the space for the dwelling. Then, laying upon them alternate beams from the four sides, they join up the angles.² And so constructing the walls with trees, they raise up towers³ rising perpendicular from the lowest parts. The gaps which are left by the thickness of the timber they block up with splinters and clay. Further, they raise the roofs by cutting off the cross-beams at the end and gradually narrowing them. And so, from the four sides they raise over the middle a pyramid on high. This they cover with leafage and clay, and, barbarian fashion, construct side to side, meeting at the corners. Thus a space is left between each beam and the beam above it.

¹ The farmhouses of the East were often in the form of towers for security's sake. "A man . . . built a tower and let it out to husbandmen." Mark xii. 1.

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efficiunt barbarico more testudinata turrium tecta.
 5 Phryges vero, qui campestribus locis sunt habitantes, propter inopiam silvarum egentes materiae ¹ eligunt tumulos naturales eosque medios fossura ² detinentes³ et itinera perfodientes dilatant spatia, quantum natura loci patitur. Insuper autem stipitis inter se religantes metas efficiunt, quas harundinibus et sarmentis tegentes exaggerabant supra habitationis ⁴ e terra maximos grumos.⁵ Ita hiemes calidissimas, aestatis frigidissimas efficiunt ⁶ tectorum rationes. Nonnulli ex ulva palustri componunt tigurina tecta. Apud ceteras quoque gentes et nonnulla loca pari similique ratione casarum perficiuntur constitutiones. Non minus etiam Massiliae animadvertere possumus sine tegulis subacta cum paleis terra tecta. Athenis Areopagi antiquitatis exemplar ad hoc tempus luto tectum. Item in Capitolio commonefacere potest et significare mores vetustatis ⁷ Romuli casa et in arce
 6 sacrorum stramentis tecta. Ita his signis de antiquis inventionibus aedificiorum, sic ea fuisse ratiocinantes, possumus iudicare.

Cum autem cotidie faciendo tritiores ⁸ manus ad aedificandum perfecissent et sollertia ingenia exercendo per consuetudinem ad artes pervenissent, tum etiam industria in animis eorum adiecta perfecit, ut,

¹ materia *G*.

² fossura *G*: forsurā *G*, fossurae *H*.

³ detegentes *Sch*: detinentes *H*.

⁴ habitationis *H*.

⁵ crumos *H*.

⁷ vetustates *H*.

⁶ efficit *H*.

⁸ tritiores *H*.

¹ The primitive character of their civilisation was proverbial.

² Marseilles was besieged by Caesar's troops 49 B.C. Vitruvius speaks as an observer.

BOOK II. c. I.

the coved roofs of their towers. 5. But the Phrygians,¹ who are dwellers in the plains, owing to the absence of forests, lack timber. Hence they choose natural mounds, and dividing them in the middle by a trench and digging tracks through, open out spaces as far as the nature of the place allows. They fasten logs together at the upper end, and so make pyramids. These they cover with reeds and brushwood and pile up very large hillocks from the ground above their dwellings. This arrangement of their dwellings makes the winter quite warm, and the summer cool. Some construct covered huts from the sedge of the marshes. Among other nations, also, in many places, the erection of huts is carried out in a parallel and similar manner. Not less also at Marseilles² we can observe roofs without tiles, made of earth and kneaded with straw. At Athens there is an ancient type of building, on the Areopagus, to this day³ covered with mud. Also in the Capitolium the Hut of Romulus,⁴ and in the Citadel, shrines covered with straw, can remind us, and signify the customs and the antiquities of Rome. 6. Thus by these examples we can infer concerning the ancient invention of buildings, reasoning that they were similar.

When, however, by daily work men had rendered their hands more hardened for building, and by practising their clever talents they had by habit acquired craftsmanship, then also the industry, which rooted itself in their minds, caused those who were

¹ Vitruvius frequently makes use of contemporary information which may be relied upon. He correctly describes the great temple of Jupiter (Zeus) as octastyle, Book III. ii. 8.

⁴ Virg. *Aen.* VIII. 654. There were two, Lanciani, *R.E.* 131.

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qui fuerunt in his studiosiores, fabros esse se profiterentur. Cum ergo haec ita fuerint primo constituta et natura non solum¹ sensibus ornavisset gentes quemadmodum reliqua animalia, sed etiam cogitationibus et consiliis armavisset mentes et subiecisset cetera animalia sub potestate, tunc vero et fabricationibus aedificiorum gradatim progressi ad ceteras artes et disciplinas, e fera agrestique vita 7 ad mansuetam perduxerunt humanitatem. Tum autem instruentes animo se eprospicientes² maioribus cogitationibus ex varietate artium natis, non casas sed etiam domos fundatas et latericiis parietibus aut e lapide structas materiaque et tegula tecta perficere coeperunt, deinde observationibus studiorum e vagantibus iudiciis et incertis ad certas symmetriarum perduxerunt rationes. Posteaquam animadverterunt profusos esse partus ab natura et materiam abundantem copiarum³ ad aedificationes ab ea comparatam, tractando nutrierunt et auctam per artes ornaverunt voluptatibus elegantiam vitae. Igitur de his rebus, quae sunt in aedificiis ad usum idoneae, quibusque sunt qualitatibus et quas habeant virtutes, ut potuero, dicam.

8 Sed si qui de ordine huius libri disputare voluerit, quod putaverit eum primum institui oportuisse, ne putet me erravisse, si credam rationem. Cum corpus architecturae scriberem, primo volumine putavi, quibus eruditionibus et disciplinis esset ornata, ex-

¹ solum *H* : plus *G*.

² *ae prosp. ante ras. H*, eprosp. *G*.

³ ab naturae materia & abundantē copiarum *H*, naturę ad materiam et abundantem copiam *G*.

¹ Vitruvius seems to have circulated copies of his first book separately.

BOOK II. c. I.

more eager herein to profess themselves craftsmen. When, therefore, these matters were so first ordained and Nature had not only equipped the human races with perceptions like other animals, but also had armed their minds with ideas and purposes, and had put the other animals under their power, then from the construction of buildings they progressed by degrees to other crafts and disciplines, and they led the way from a savage and rustic life to a peaceful civilisation. 7. Then, however, building up themselves in spirit, and looking out and forward with larger ideas born from the variety of their crafts, they began to build, not huts, but houses, on foundations, and with brick walls, or built of stone; and with roofs of wood and tiles. Then by the observations made in their studies they were led on from wandering and uncertain judgments to the assured method of symmetry. When they observed that Nature brought forth profusely, and provided materials abounding in usefulness for building, they handled them with fostering care, and equipped with delights the refinement of life, increased as it was by their several crafts. Therefore, concerning the things which are fit for use in buildings, of what qualities they are and what virtues they possess, I will speak as I am able.

8. But if anybody raises objections about the arrangement of the whole work, because he thinks that this book should have come first,¹ let him not think I have erred, if I believe in Reason.² When I wrote this comprehensive treatise on architecture, I thought in the first book to set forth with what trainings and disciplines architecture was equipped,

² H. retains his creed : *credo rationem*; *credo* with the acc. is found in some early creeds.

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ponere finireque terminationibus eius species et, e quibus rebus esset nata, dicere. Itaque quid oporteat esse in architecto, ibi pronuntiavi. Ergo in primo de artis officio, in hoc de naturalibus materiae rebus, quem habeant usum, disputabo. Namque hic liber non profitetur, unde architectura nascatur, sed unde origines aedificiorum sunt institutae et quibus rationibus enutritae et progressae sint gradatim ad 9 hanc finitionem. Ergo ita suo ordine et loco huius erit voluminis constitutio.

Nunc revertar ad propositum et de copiis, quae aptae sunt aedificiorum perfectionibus, quemadmodum videantur esse ab natura rerum procreatae quibusque mixtionibus principiorum congressus temperentur, nec obscura sed perspicua legentibus sint, ratiocinabor. Namque nulla materiarum genera neque corpora neque res sine principiorum coetu nasci neque subici intellectui possunt, neque aliter natura rerum praeceptis physicorum veras patitur habere explicationes, nisi causae, quae insunt in his rebus quemadmodum et quid ita sint, subtilibus rationibus habeant demonstrationes.

II

- 1 THALES¹ primum aquam putavit omnium rerum esse principium; Heraclitus Ephesius, qui propter obscuritatem scriptorum a Graecis *scoteinos*² est appellatus, ignem; Democritus quique est eum

¹ Tales H.

² scotinos H.

BOOK II. c. I.—c. II.

and to determine by definitions its species and to say from what things it sprang. And so I there pronounced what there ought to be in an architect. Therefore in the first book I discussed the office of the architect. In this book I will treat of the material things of nature, and what uses they have. For this book does not declare whence architecture arises, but whence the kinds of building have originated, and by what ways they have been fostered and, by degrees, advanced to their present finish. 9. So therefore the arrangement of this book is in its order and place.

Now I will return to my undertaking and will deal with the materials which are adapted to the execution of buildings; how they seem to be generated by Nature, and in what mixtures the assemblages of elements are blended. These, indeed, are not obscure but obvious to my readers. For no kinds of materials, nor bodies, nor things can arise or be subject to the intelligence without the coming together of elements, nor does Nature allow them to have true explanations in the precepts of physicists, unless the causes which are present in these things find proofs, how and why they are so, by accurate demonstrations.

CHAPTER II

ON THE PRINCIPLES OF THINGS

1. FIRST, Thales¹ thought that *water* was the principle of all things. Heraclitus of Ephesus (who because of the obscurity of his writings was called Dark by the Greeks), *fire*; Democritus, and Epicurus

¹ Vitruvius' list of philosophers was probably taken from Varro, who in turn drew upon a late Greek compilation of the opinions of philosophers, Diels, *Doxographi Graeci*, 94, 200.

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secutus Epicurus *atomos*, quas¹ nostri insecabilia corpora, nonnulli individua vocitaverunt; Pythagoreorum vero disciplina adiecit ad aquam et ignem aera² et terrenum. Ergo Democritus, etsi non proprie res nominavit sed tantum individua corpora proposuit, ideo ea ipsa dixisse videtur, quod ea, cum sint disiuncta, nec laeduntur³ nec interitionem recipiunt nec sectionibus dividuntur, sed sempiterno aevo perpetuo
2 infinitam retinent in se soliditatem. Ex his ergo congruentibus cum res omnes coire nascique videantur et hae in infinitis generibus rerum natura essent disparatae, putavi oportere de varietatibus et discrimini-
bus usus earum quasque haberent in aedificiis qualitates exponere, uti, cum fuerint notae, non habeant qui aedificare cogitant errorem, sed aptas ad usum copias aedificiis conparent.

III

1 ITAQUE primum de lateribus, qua de terra duci eos oporteat, dicam. Non enim de harenoso neque calculoso luto neque sabulono luto sunt ducendi, quod, ex his generibus cum sint ducti, primum fiunt graves, deinde, cum ab inbribus⁴ in parietibus sparguntur, dilabuntur et dissolvuntur paleaeque in

¹ quas *Ro*: quos *H*.

² aera *G*: aerea *H*.

³ nec laeduntur *rec*: nec leguntur *H G*.

⁴ inbribus *H*.

¹ *insecabilia*: found in Seneca and Quintilian.

² *individua*: Cicero.

³ "Things" were uncertain in Democritus' system. Book VII. pref. 11.

BOOK II. c. II.—c. III.

who followed him, *atoms*, which our writers have called unbreakables,¹ some *indivisibles*.² But the school of the Pythagoreans added *air* and the *earthy* to water and fire. Therefore Democritus, although he did not name “things”³ as such, but supposed “atoms” only, seems to have spoken of them as such because although they may be separated out, they are not damaged nor destroyed, nor cut up into parts, but retain in themselves for ever a perfect solidity. 2. Since therefore from these, being in correspondence, all things seem to come together and be born, and since by Nature they have been divided into infinite kinds, I thought I ought first to deal with the varieties and differences of the use of them, and what qualities they show in buildings; so that when they are familiar, those who think of building may not make mistakes but get supplies fit for use.

CHAPTER III

ON BRICKS

1. THEREFORE, first I will speak about bricks, and from what kind of clay they ought to be brought. For they ought not to be made from sandy nor chalky soil nor gravelly soil: because when they are got from these formations, first they become heavy, then, when they are moistened by rain showers in the walls, they come apart and are dissolved. And the straw does not stick in them⁴

⁴ The addition of straw to bricks increased their breaking strength by 244 per cent. Straw was used along with leaves of plants and parts of grasses in Egypt. Neuburger, *tr.* 137.

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his non cohaerescunt propter asperitatem. Faciendi autem sunt ex terra albida cretosa sive de rubrica aut etiam masculo sabulone; haec enim genera propter levitatem habent firmitatem et non sunt in
² opere ponderosa et faciliter aggerantur. Ducendi autem sunt per vernum tempus et autumnale, ut uno tempore¹ siccescant. Qui enim per solstitium parantur, ideo vitiosi fiunt, quod, summum corium² sol acriter cum praecoquit, efficit ut videatur aridum, interior autem sit non siccus; et cum postea siccescendo se contrahit, perrumpit ea quae erant arida. Ita rimosi facti efficiuntur imbecilli. Maxime autem utiliores erunt, si ante biennium fuerint ducti; namque non ante possunt penitus siccescere. Itaque cum recentes et non aridi sunt structi, tectorio inducto rigidoque obsolidati permanent; ipsi sidentes³ non possunt eandem altitudinem qua est tectorium, tenere, contractioneque moti non haerent cum eo, sed ab coniunctione eius disparantur; igitur tectoria ab structura seiuncta propter tenuitatem per se stare non possunt, sed franguntur, ipsique parietes fortuito sidentes vitiantur. Ideo etiam Uticenses laterem, si sit aridus et ante quinquennium ductus, cum arbitrio magistratus fuerit ita probatus, tunc utuntur
³ in parietum structuris. Fiunt autem laterum genera tria: unum, quod graece Lydium appellatur, id est

¹ tenore *Joc*: tempore *H*. ² chorium *H*.

³ sidentes *S*²: sedentes *H*.

¹ Sun-dried bricks, *lateres*, used under the republic; kiln-baked bricks under Early Empire, *testae*. Stuart Jones, *Companion to Roman History*, 56.

² In Tunis, about 25 miles from Carthage. Vitruvius probably speaks from direct knowledge. He was a friend

BOOK II. c. III.

because of their roughness. But bricks are to be made of white clayey earth or of red earth, or even of rough gravel. For these kinds, because of their smoothness, are durable. They are not heavy in working, and are easily built up together. 2. Now bricks are to be made either in the spring or autumn, that they may dry at one and the same time. For those which are prepared at the summer solstice become faulty for this reason: when the sun¹ is keen and overbakes the top skin, it makes it seem dry, while the interior of the brick is not dried. And when afterwards it is contracted by drying, it breaks up what was previously dried. Thus bricks crack and are rendered weak. But, most especially, they will be more fit for use if they are made two years before. For they cannot dry throughout before. Therefore when they are built in fresh and not dry, and the plaster is put on and becomes rigid, they remain solid only on the surface. Hence they settle and cannot keep the same height as the plaster. For by contraction and the consequent movement they cease to stick to the plaster, and are separated from their union with it. Therefore the wall-surfaces are separated from the wall itself, and because of their thinness cannot stand of themselves and are broken, and the walls settling haphazard, become faulty. That is why the citizens of Utica² use no bricks for building walls, unless the magistrate has approved them as being dry and made five years before. 3. Now there are three kinds of bricks: one which in Greek is called

of a neighbouring landowner, Book VIII. iv. 25. In Roman towns, building operations were controlled by the aediles. Even villages had their aedile. Arnold, *Roman Provincial Administration*, 217.

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quo nostri utuntur, longum sesquipede, latum pede. Ceteris duobus Graecorum aedificia struuntur; ex his unum *pentadoron*, alterum *tetradoron* dicitur. *Doron* autem Gracei appellant palmum, quod munerum datio graece *doron* appellatur, id autem semper geritur per manus palmum. Ita quod est quoquo versus quinque¹ palmorum, *pentadoron*, quod quattuor, *tetradoron* dicitur, et quae sunt publica opera, *pentadorōs*, quae privata, *tetradorōs* struuntur. 4. Fiunt autem cum his lateribus semilateria. Quae cum struuntur, una parte lateribus ordines, altera semilateresponuntur. Ergo ex utraque parte ad lineam cum struuntur,² alternis coriis parietes alligantur et medii lateres supra coagmenta conlocati et firmitatem et speciem faciunt utraque parte non invenustam.

Est autem in Hispania ulteriore civitas Maxilua³ et Callet⁴ et in Asia Pitane,⁵ ubi lateres cum sunt ducti et arefacti, proiecti natant in aqua. Natare autem eos posse ideo videtur, quod terra est, de qua ducuntur, pumicosa. Ita cum est levis, aere solidata non recipit in se nec combibit liquorem. Igitur levi raraque cum sit proprietate, nec patiantur penetrare in corpus umidam potestatem, quocumque pondere fuerit, cogitur ab rerum natura, quemadmodum pumex, uti ab aqua sustineatur, sic autem magnas

¹ quinque *G*: equinque *H*.

² cum str. *H*: construuntur *G*.

³ Maxilua *Voss*: maxima *H*.

⁴ Callet *Plin.* 35, 171: in galliis *H*.

⁵ Pitane *Joc*: ita ne *H*.

BOOK II. c. III.

Lydion, that is the one which we use, a foot and a half long, a foot wide. Greek buildings are constructed with the other two. Of these, one is called *pentadoron*, the other *tetradoron*. Now the Greeks call the palm *doron*, because the giving of gifts is called *doron*, and this is always done by means of the palm of the hand. Thus the brick that is of five palms every way is called *pentadoron*; of four palms, *tetradoron*. Public buildings are erected with the former; private buildings with the latter. 4. Along with these bricks, half-bricks also are made. When these are built to the line of the face, on one side courses¹ are laid with bricks, on the other side half-bricks are laid. The walls are bound together by the alternate facings²; and the middle of the bricks, being placed above the joints, produces firmness, and a not displeasing appearance on either side.

Now in Further Spain there is a town *Maxilua*, and also *Callet*, in Asia there is *Pitane*,³ where bricks, when they have been made and dried, swim in water if they are thrown in. Now it seems that they are able to swim because the soil from which they are drawn is like pumice. Thus, since it is light, when made solid by the air it does not admit nor drink up moisture into itself. Therefore since these bricks are of a light and open property, and do not allow the humid potency to penetrate into the body, of whatever weight the body shall be, it is compelled by Nature to be upheld by water like pumice-stone.

¹ *ordo* = course. *Vulg. III. Reg. vi. 36: Tres ordines lapidum.*

² *Corium*, like skin or leather; then it comes to mean facing. The wall is $1\frac{1}{2}$ bricks thick. The whole bricks overlap half in the middle of the wall.

³ In Mysia.

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habent utilitates, quod neque in aedificationibus sunt onerosi et cum ducuntur a tempestatibus non dissolvuntur.

IV

- 1 IN caementiciis autem structuris primum est de harena quaerendum, ut ea sit idonea ad materiem miscendam neque habeat terram commixtam. Genera autem harenae fossiciae sunt haec: nigra, cana, rubra, carbunculum. Ex his, quae in manu confricata, vel icta fecerit stridorem, erit optima; quae autem terrosa fuerit, non habebit asperitatem. Item si in vestimentum candidum ea contexta fuerit, postea excussa aut icta id non inquinari neque ibi
2 terra subsiderit, erit idonea. Sin autem non erunt harenaria, unde fodiatur, tum de fluminibus aut e glarea erit excernenda, non minus etiam de litore marino. Sed ea in structuris haec habet vitia: difficulter siccescit,¹ neque onerari se continenter recipit; paries patitur, nisi intermissionibus requiescat, neque concamerationes recipit. Marina autem hoc amplius, quod etiam parietes, cum in is tectoria facta fuerint, remittentes salsuginem eorum dissolvuntur.
3 Fossiciae vero celeriter in structuris siccescunt, et tectoria permanent, et concamerationes patiuntur, sed hae, quae sunt de harenariis recentes. Si enim exemptae diutius iacent, ab sole et luna et pruina

¹ siccescit *S* : siccessit *H*.

¹ *Caementum* = concrete according to Stuart Jones, *op. cit.* 55.

² As in arched ceilings of concrete.

BOOK II. c. III.—c. IV.

So indeed they have great advantages because they are not heavy in buildings, and when they are being made, they are not dissolved by storms.

CHAPTER IV

ON SAND

1. Now in rubble ¹ structures we must first inquire about the sand, that it be suitable for mixing material into mortar, and without the admixture of earth. Now the kinds of quarried sand are these: black, white, red, and from lignite. Of these, that which makes a noise when rubbed in the hand will be best; but that which is earthy will not have a like roughness. Also, if it is covered up in a white cloth, and afterwards shaken up or beaten, and does not foul it, and the earth does not settle therein, it will be suitable. 2. But if there are no sand-pits whence it may be dug, then it must be sifted out from the river bed or from gravel, not less also from the sea-shore. But such sand has these faults in buildings: it dries with difficulty, nor does the wall allow itself to be loaded continuously without interruptions for rest, nor does it allow of vaulting.² But in the case of sea sand, when plastered surfaces ³ are laid upon walls, the walls discharge the salt of the sands and are broken up. 3. But quarry sand quickly dries in buildings, and the surface lasts; and it admits of vaulting, but only that which is fresh from the pit. For if after being taken out it lies too long, it is weathered by the sun and the moon and the hoar

³ *Opus tectorium* = stucco.

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concoctae resolvuntur et fiunt terrosae. Ita cum in structuram coiciuntur, non possunt continere caementa, sed ea¹ ruunt et labuntur oneraque parietes non possunt sustinere. Recentes autem fossiciae cum in structuris tantas habeant virtutes, eae in tectoriis ideo non sunt utiles, quod pinguitudini eius calx palea commixta, propter vehementiam non potest sine rimis inarescere. Fluviatica vero propter macritatem uti signinum liaculorum subactionibus in tectorio recipit soliditatem.

V

- 1 DE harenae copiis cum habeatur explicatum, tum etiam de calce diligentia est adhibenda, uti de albosaxo aut silice coquatur²; et quae erit ex spisso et duriore, erit utilis in structura, quae autem ex fistuloso, in tectoriis. Cum ea erit extincta, tunc materia ita misceatur, ut, si erit fossicia, tres harenae et una calcis infundatur; si autem fluviatica aut marina, duo harenae una calcis coiciatur. Ita enim erit iusta ratio mixtionis temperaturae. Etiam in fluviatica aut marina si qui testam tunsam et succretam ex

¹ ea ruunt *G*: earunt *H*.

² quoquatur *H*.

¹ Cow-dung is used to-day in pargetting chimneys, probably because of the vegetable matter contained in it.

² A town of Latium.

BOOK II. c. iv.—c. v.

frost, and is dissolved and becomes earthy. Thus when it is thrown into the rubble, it cannot bind together the rough stones, but these collapse and the loads give way which the walls cannot maintain. But while fresh pit sand has such virtues in buildings, it is not useful in plaster work; because owing to its richness, the lime when mingled with straw¹ cannot, because of its strength, dry without cracks. But river sand because of its fineness (like that from Signia²), when it is worked over with polishing tools,³ acquires solidity in the plaster.

CHAPTER V

ON LIME

1. AFTER furnishing an account of the supply of sand, we must next be careful about *lime*, to burn it out of white stone or lava⁴; the lime which shall be out of thick and harder stone will be useful in the main structure; that which shall be of porous material, in plaster work. When it is slaked, then let it be mingled with the sand in such a way that if it is pit sand, three of sand and one of lime is poured in; but if the sand is from the river or sea, two of sand and one of lime is thrown together. For in this way there will be the right proportion of the mixture and blending. Also in the case of river or sea sand, if anyone adds crushed and sifted potsherds in the proportion

³ Tertullian describes plasterer's work: *scit albarius tector et tecta sarcire et tectoria inducere et cisternam liare et cymatia distendere. Idol. 8.*

⁴ Silix, quarried from four lava streams, under the charge of the *Procurator ad silices*. Lanciani, *R.E.* 37.

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tertia parte adiecerit, efficiet materiae temperaturam
2 ad usum meliorem. Quare autem cum recipit aquam
et harenam calx, tunc confirmat structuram, haec esse
causa videtur, quod e principiis, uti cetera corpora,
ita et saxa sunt temperata. Et quae plus habent
aeris, sunt tenera; quae aquae, lenta sunt ab umore;
quae terrae, dura¹; quae ignis, fragiliora. Itaque ex
his saxa si, antequam coquantur, contusa minute
mixta harenae in instructuram coiciantur, non solide-
scunt nec eam poterunt continere. Cum vero coniecta
in fornacem ignis vehementi fervore correpta amiserint
pristinæ soliditatis virtutem, tunc exustis atque ex-
haustis eorum viribus relinquuntur patentibus forami-
3 nibus et inanibus. Ergo liquor, qui est in eius lapidis
corpore, et aer cum exustus et ereptus fuerit, habue-
ritque in se residuum calorem latentem, intinctus
in aqua, prius quam ex igni vim recepit umore pene-
trante in foraminum raritates, confervescit et ita
refrigeratus reicit ex calcis corpore fervorem. (Ideo
autem, quo pondere saxa coiciuntur in fornacem,
cum eximuntur, non possunt ad id respondere, sed
cum expenduntur, permanente ea magnitudine,
excocto liquore circiter tertia parte ponderis inminuta
esse inveniuntur.) Igitur cum patent foramina
eorum et raritates, harenae mixtionem in se corripiunt
et ita cohaerescunt siccescendoque cum caementis
coeunt et efficiunt structurarum soliditatem.

¹ duræ H.

¹ Cato, *Agri. cult.* XXXVIII. 1. Still in use. Neuburger, 407.

BOOK II. c. v.

of one to three, he will produce a blending of material which is better for use. 2. And so when lime receives water and sand and then strengthens the structure, the following seems to be the cause: just as other bodies, so also stones are blended of the elements. And those which have more air are soft; more water, are pliant from the moisture; more earth, are hard; more fire, are more fragile. Therefore if stones of this last quality are crushed before they are burnt, and mixed with sand, and thrown into the work, they do not become solid, nor can they hold the building together. But when they are thrown into the kiln,¹ they are seized by the violent heat of the fire and lose the virtue of their former solidity. Their strength is burnt out and exhausted and they are left with open and empty pores. 3. Therefore when the moisture which is in the body of that stone, and the air, are burnt out and removed, and the stone retains the remaining latent heat, on being plunged into water (before it recovers power from fire), the moisture penetrates into the open pores, and it seethes and thus, being cooled again, it rejects the heat from the substance of the lime. Thus, moreover, whatever weight the stone possesses when it is thrown into the kiln, it cannot answer to that ² when it is taken out; but when it is weighed, the bulk remaining the same, it is found to lose about one-third of its weight when the moisture is burnt out. Therefore, when the pores and attenuations of the lime are open, it catches up into itself the mixture of the sand; thus it coheres and, as it dries, joins with the rubble and produces solid walling

² This anticipation of the discovery of oxygen is noteworthy.

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VI

1 Est etiam genus pulveris, quod efficit naturaliter res admirandas. Nascitur in regionibus Baianis in agris municipiorum, quae sunt circa Vesuvium montem. Quod conmixtum cum calce et caemento non modo ceteris aedificiis praestat firmitates, sed etiam moles cum struuntur in mari, sub aqua solidescunt. Hoc autem fieri hac ratione videtur, quod sub his montibus et terrae ferventes sunt et fontes crebri, qui non essent si non in imo haberent aut e sulphure aut alumine aut bitumine ardentes maximos ignes. Igitur penitus ignis et flammae vapor per intervenia permanans et ardens efficit levem eam terram, et ibi quod nascitur tofus exurgens,¹ est sine liquore. Ergo cum tres res consimili ratione ignis vehementia formatae² in unam pervenerint mixtionem, repente recepto liquore una cohaerescunt et celeriter umore duratae solidantur, neque eas fluctus neque vis aquae² potest dissolvere. Ardores autem esse in his locis etiam haec res potest indicare, quod in montibus Cumanorum³ Baianis sunt loca sudationibus excavata, in quibus vapor fervidus ab imo nascens ignis vehementia perforat eam terram per eamque manando⁴ in his locis oritur et ita sudationum egregias

¹ exurgens *H*: exurgens *G*.

² foratae *Nohl*: formatae *H*.

³ cumannorum *H S*.

⁴ post manando, fervidus ab imo nascens *repetit H*.

¹ Baiae on the Bay of Naples, near the northern end. It was a luxurious watering-place visited in April for the hot medicinal springs.

BOOK II. c. vi.

CHAPTER VI

ON POZZOLANA

1. THERE is also a kind of powder which, by nature, produces wonderful results. It is found in the neighbourhood of Baiae¹ and in the lands of the municipalities round Mount Vesuvius. This being mixed with lime and rubble, not only furnishes strength to other buildings, but also, when piers² are built in the sea, they set under water. Now this seems to happen for this reason: that under these mountainous regions there are both hot earth and many springs. And these would not be unless deep down they had huge blazing fires of sulphur, alum or pitch. Therefore the fire and vapour of flame within, flowing through the cracks, makes that earth light. And the tufa which is found to come up there is free from moisture. Therefore, when three substances formed in like manner by the violence of fire come into one mixture, they suddenly take up water and cohere together. They are quickly hardened by the moisture and made solid, and can be dissolved neither by the waves nor the power of water. 2. But that there are fervent heats in these districts may be proved by this circumstance. In the hills of Baiae which belong to Cumae³ sites are excavated for sweating-rooms.⁴ In these hot vapour rising deep down perforates the soil by the violence of its heat, and passing through it rises in these places, and so produces striking advantages in sweating-

² *Contracta pisces aequora sentiunt iactis in altum molibus.*
Hor. *Odes*, III. i. 33.

³ Cumae north of Baiae, across the promontory of Misenum.

⁴ Also called Laconicum.

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efficit utilitates. Non minus etiam memorentur¹ antiquitus crevisse ardores et abundavisse sub Vesuvio monte et inde evomuisse circa agros flammam. Ideoque tunc quae spongia sive pumex Pompeianus vocatur excocto ex alio genere lapidis in
 3 hanc redacta esse videtur generis qualitatem. Id autem genus spongiae, quod inde eximitur, non in omnibus locis nascitur nisi circum Aetnam et collibus Mysiae, quae a Graecis *Catacecaumene* nominatur, et si quae eiusdem modi sunt locorum proprietates. Si ergo in his locis aquarum ferventes inveniuntur fontes et omnibus excavatis calidi vapores ipsaque loca ab antiquis memorantur pervagantes in agris habuisse ardores, videtur esse certum ab ignis vehementia ex tofo terraque, quemadmodum in fornacibus et a
 4 calce, ita ex his ereptum esse liquorem. Igitur dissimilibus et disparibus rebus correptis et in unam potestatem conlatis, calida umoris ieiunitas aqua² repente satiata communibus corporibus latenti calore confervescit et vehementer efficit ea coire celeriterque unam soliditatis percipere virtutem.

Relinquetur desideratio, quoniam ita sunt in Etruria ex aqua calida crebri fontes, quid ita non etiam ibi nascitur pulvis, e quo eadem ratione sub aqua structura solidescat. Itaque visum est, antequam desideraretur, de his rebus, quemadmodum
 5 esse videantur, exponere. Omnibus locis et regionibus non eadem genera terrae nec lapides nascuntur, sed nonnulla sunt terrena, alia sabulosa itemque glareosa,³ aliis locis harenosa, non minus materia, et

¹ memorantur *G*: memorentur *H*.

² aquae *H*.

³ glareosa *G*: glariosa *H*.

¹ Burnt land.

BOOK II. c. vi.

rooms. Not less also let it be recorded, that heats in antiquity grew and abounded under Mount Vesuvius, and thence belched forth flame round the country. And therefore now that which is called "sponge-stone" or Pompeian pumice seems to be brought to this general quality from another kind of stone when it is subjected to heat. 3. But that kind of sponge stone which is taken thence is not found in all places, only round Etna and on the hills of Mysia (which is called *Catacecaumene*¹ by the Greeks), and if there are in any other places properties of that kind. If, therefore, in these places there are found hot springs, and in all excavations, warm vapours, and if the very places are related by the ancients to have had fires ranging over the fields, it seems to be certain that by the violence of fire, moisture has been removed from the tufa and earth just as from lime in kilns. 4. Therefore, when unlike and unequal substances are caught together and brought into one nature, the hot desiccation, suddenly saturated with water, seethes together with the latent heat in the bodies affected, and causes them to combine vehemently and to gain rapidly one strong solidity.

Since in Etruria² also there are frequent springs of hot water, there will remain the inquiry why there also the powder is not found, from which in the same manner walling may set under water. Therefore it seemed good, before inquiry was made on these matters, to set forth how they seemed to come about. 5. Neither the same kinds of soil nor the same rocks are found in all places and regions, but some are earthy, others of gravel, others pebbly, in other places sandy material; and generally there are

² Etruria distinguished from Italy.

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omnino dissimili disparique genere in regionum varietatibus qualitates insunt in terra. Maxime autem id sic licet¹ considerare, quod, qua mons Appenninus regionis Italiae Etruriaequae circa cingit, prope in omnibus locis non desunt fossicia harenaria, trans Appenninum vero, quae pars est ad² Adriaticum mare, nulla inveniuntur, item Achaia, Asia, omnino trans mare, nec nominatur quidem. Igitur non in omnibus locis, quibus effervent aquae calidae crebri fontes, eadem³ opportunitates possunt similiter concurrere, sed omnia, uti natura rerum constituit, non ad voluntatem hominum, sed ut fortuito disparata procreantur. Ergo quibus locis non sunt terrosi montes sed genere materiae, ignis vis per eius venas egrediens adurit eam. Quod est molle et tenerum, exurit, quod autem asperum, relinquit. Itaque uti Campania exusta terra cinis, sic in Etruria excoccta materia efficitur carbunculus. Utraque autem sunt egregia in structuris, sed alia in terrenis aedificiis, alia etiam in maritimis molibus habent virtutem. Est autem materiae potestas mollior quam tofus, solidior quam terra, quo penitus ab uno vehementia vaporis adusto, nonnullis locis procreatur id genus harenae quod dicitur carbunculus.

VII

- 1 DE calce et harena, quibus varietatibus sint et quas habeant virtutes, dixi. Sequitur ordo de lapi-

¹ sic licet *rec* : scilicet *H.*

² ad *om.* *H.*

³ edem opportunitatis *H.*

¹ Province including most of modern Greece.

² Province of Asia Minor.

BOOK II. c. VI.—c. VII.

found in the earth qualities of unlike and unequal kind with the various regions. But we may regard the matter especially in this way: almost everywhere, where the Apennine range encloses the regions of Italy and Etruria, sand-pits are found; whereas across the Apennines, where the land adjoins the Adriatic, none are found. Generally also it is not indeed even named across the sea in Achaia¹ and Asia.² Therefore not in all places in which frequent hot springs boil up can the same conveniences arise; but all things are generated as the Nature of Things has determined, not for the pleasure of man, but disparate as though by chance. 6. Therefore wherever mountains are not of earth but of a woody kind, the force of fire escaping through the veins burns it up. It burns out what is soft and tender, but leaves what is rough. Therefore just as in Campania, burnt-out earth becomes ashes, so in Etruria, charred stone becomes carbuncular. Both are excellent in walling. But some materials have advantages in buildings on land, and others in piers built into the sea. The nature of wood is softer than tufa, more solid than the earth³; and when this is burnt deep down by the violence of vapour, there is generated in some places that kind of sand which is called lignite (carbunculus).

CHAPTER VII

ON STONE

1. I HAVE spoken of lime and sand, both of what varieties they are and what virtues they possess. Next in order comes the description of the quarries

³ This statement is possible on Vitruvius' principles.

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dicinis explicare, de quibus et quadrata saxa et caementorum ad aedificia eximuntur copiae et comparantur. Haec autem inveniuntur esse disparibus et dissimilibus virtutibus. Sunt enim aliae molles, uti sunt circa urbem Rubrae, Pallenses, Fidenates, Albanae; aliae temperatae, uti Tiburtinae,¹ Amiterninae, Soractinae et quae sunt his generibus; nonnullae durae, uti siliceae.² Sunt etiam alia genera plura, uti in Campania rubrum et nigrum tofum, in Umbria et Piceno et in Venetia² albus, quod etiam serra dentata utilignum secatur. Sed haec omnia quae mollia sunt, hanc habent utilitatem, quod ex his saxa cum sunt exempta, in opere faciliter tractantur. Et si sunt in locis tectis, sustineant laborem, si autem in apertis et patentibus, gelicidiis et pruina congesta friantur³ et dissolvuntur. Item secundum oram maritimam⁴ ab alsugine exesa⁵ diffluunt neque perferunt aestus. Tiburtina vero et quae eodem genere sunt omnia, sufferunt et ab oneribus et a tempestatibus iniurias, sed ab igni non possunt esse tuta, simulque sunt ab eo tacta, dissiliunt et dissipantur, ideo quod temperatura naturali parvo sunt umore itemque non multum habent terreni, sed aeris plurimum et ignis. Igitur cum et umor et

¹ tibertinae *H.*

² siliciae *H.*

³ friantur *H*: fricantur *G.*

⁴ oram maritimam *rec*: ora maritima *H.*

⁵ exesa *ed. Fl*: exea *H.*

¹ Of tufa, in the city.

² Not known.

³ Castel Giubileo, 5 m. north of Rome, hill of tufa.

⁴ Lapis Albanus or Peperino of grey colour.

⁵ Lapis Tiburtinus or Travertine, yellowish-white limestone. Up to Sulla's time, little used.

⁶ In Sabine country.

BOOK II. c. vii.

from which both squared stone and supplies of rubble are taken and furnished for buildings. Now these are found to be of unequal and unlike virtues. For some are soft, as they are in the neighbourhood of the city at Grotta Rossa,¹ Palla², Fidenae³ and Alba⁴; others are medium, as at Tivoli,⁵ Amiternum,⁶ Soracte,⁷ and those which are of these kinds; some hard, like lava. There are also many other kinds, as red and black tufa in Campania⁸; in Umbria and Picenum and in Venetia, white stone which indeed is cut, like wood, with a toothed saw.⁹ 2. But all these quarries which are of soft stone have this advantage: when stones are taken from these quarries they are easily handled in working, and if they are in covered places, they sustain their burden, but if they are in open and exposed places, they combine with ice and hoar frost, are turned to powder and are dissolved: along the sea-coast, also, being weathered by the brine, they crumble and do not endure the heat. Travertine, however, and all stones which are of the same kind, withstand injury from heavy loads and from storms; but from fire they cannot be safe¹⁰; as soon as they are touched by it they crack and break up. And the reason is that by the nature of their composition they have little moisture and also not much earth, but much air and fire. Therefore, since

¹ Limestone ridge north of Rome.

² The tufa period at Pompeii preceded the sending of a colony of Roman soldiers, 80 B.C.

³ Saws were used in Egypt worked by hand; later also in Rome. Sawmills worked by water-power were used on the Moselle in the fourth cent. A.D. Cf. *trahens per levia marmora serras*. Auson. *Mosella*, 363.

¹⁰ Lapis Albanus, peperino, as resisting fire was ordered to be used by Nero, after the fire at Rome. Tac. *Ann.* XV. 43.

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terrenum¹ in his minus inest, tum etiam ignis, tactu et vi vaporis ex his aere fugato, penitus insequens interveniorum² vacuitates occupans fervescit et
 3 efficit a suis ardentia corporibus similia. Sunt vero item lapidicinae conplures in finibus Tarquiniensium, quae dicuntur Anicianae, colore quemadmodum Albanae, quorum officinae maxime sunt circa lacum Vulsiniensem, item praefectura Statonensi. Haec autem habent infinitas virtutes; neque enim his gelidiorum tempestas neque ignis tactus potest nocere, sed est firma et ad vetustatem ideo permanens, quod parum habet e naturae mixtione aeris et ignis, umoris autem temperate plurimumque terreni. Ita spissis conparationibus solidata neque ab tempestati-
 4 bus neque ab ignis vehementia nocetur. Id autem maxime iudicare licet e monumentis, quae sunt circa municipium Ferenti³ ex his facta lapidicinis. Namque habent et statuas amplas factas egregie et minora sigilla floresque et acanthos eleganter scalptos⁴; quae, cum sint vetusta, sic apparent recentia, uti si sint modo facta. Non minus etiam fabri aerarii de his lapidicinis in aeris flatu formas⁵ comparatas⁶ habent; ex his ad aes fundendum maximas utilitates. Quae si prope urbem essent, dignum esset, ut ex his officinis omnia opera per-
 5 ficerentur. Cum ergo propter propinquitatem

¹ terrenum *ed* : -nus *H*.

² interveniorum *Joc* : inter venarum *H*.

³ Ferenti *Mar* : ferentis *H*. ⁴ scalptos *H* : sculptos *G*.

⁵ formas *G*. ⁶ comparatis *rec* : comparatas *H*.

¹ Corneto on the coast, 60 miles n. of Rome.

² Cf. Dennis, *Cities and Cemeteries of Etruria*, C. XIII. The Anician house was represented by a praetor in the third

BOOK II. c. vii.

there is less moisture and earth in these, then also the fire, when the air has been expelled by the contact and violence of the heat, following far within and seizing upon the empty spaces of the fissures, seethes and produces, from its own substance, similar burning bodies. 3. But there are also several quarries in the neighbourhood of Tarquinii,¹ known as the Anician,² in colour like those of Alba, of which the workings are mostly round the lake of Bolsena,³ and also in the prefecture of Statonia.⁴ These also have infinite virtues; for they can neither be injured by weathering under frost nor by the approach of fire. But the stone is firm and wears well over a long time, because it has little air and fire in its natural mixture, a medium amount of moisture, and much of the earthy. Thus solidified by its close composition, it is injured⁵ neither by weathering nor by the violence of fire. 4. Now this we may especially judge from the monuments, which are about the municipality of Ferentum,⁶ made from these quarries. For they have large statues strikingly made, and lesser figures and flowers and acanthus finely carved. These, old as they are, appear as fresh as if they were just made. None the less also, coppersmiths in their bronze castings get moulds from these quarries, and find great advantages from them for casting bronze. And if these were near the city, it would be worth while to execute all works from these stoneyards. 5. Since then, because of their nearness, necessity Macedonian war, by friends of Cicero; later it became the first family in Rome.

¹ Dennis, *op. cit.* C. XXVII. ⁴ Dennis, *op. cit.* C. XXIV.

² *nocetur*: a striking solecism.

⁶ Near Viterbo; not to be confused with town of same name in Apulia. The monuments were probably in part sarcophagi.

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necessitas cogat ex Rubris lapidicinis et Pallensibus et quae sunt urbi proximae copiis uti, si qui voluerit sine vitiis perficere, ita erit praeparandum. Cum aedificandum fuerit, ante biennium ea saxa non hieme sed aestate eximantur et iacentia permaneant in locis patentibus. Quae autem eo biennio a tempestatibus tacta laesa fuerint, ea in fundamenta coiciantur; cetera, quae non erunt vitiata, ab natura rerum probata durare poterunt supra terram aedificata. Nec solum ea in quadratis lapidibus sunt observanda, sed etiam in caementiciis structuris.

VIII

- 1 STRUCTURARUM genera sunt haec: reticulatum quo nunc omnes utuntur, et antiquum quod incertum dicitur. Ex his venustius est reticulatum, sed ad rimas faciendas ideo paratum, quod in omnes partes dissoluta habet cubilia et coagmenta. Incerta vero caementa alia super alia sedentia inter seque inbricata non speciosam sed firmiorem quam reticulata
2 praestant structuram. Utraque autem ex minutissimis sunt instruenda, uti materia ex calce et harena crebriter parietes satiati diutius contineantur. Molli enim et rara potestate cum sint, exsiccant sugendo e materia sucum; cum autem superarit et abundarit copia calcis et harenae, paries ¹ plus habens

¹ paries *rec* : partes *H*.

¹ The *opus incertum* was given up about the time of Sulla, and replaced by the *opus reticulatum*, made of tufa prisms in imitation of network. Lanciani, *R.E.* 45. This lasted till the time of the Antonines.

BOOK II. C. VII.—C. VIII.

compels the use of supplies from the quarries of Grotta Rossa and Palla, and others which are nearest to the city, we must take precautions if we wish to complete our work without faults. When we have to build, let the stone be got out two years before, not in winter but in summer, and let it lie and stay in exposed places. Those stones, however, which in the two years suffer damage by weathering, are to be thrown into the foundations. Those which are not faulty are tested by Nature, and can endure when used in building above ground. And these precautions are to be taken not only in the case of squared stones, but also for rough stone or rubble walling.

CHAPTER VIII

ON WALLING

1. THERE are two kinds of walling; one like network, *opus reticulatum*,¹ which all use now, and the old manner which is called *opus incertum*.¹ Of these the *reticulatum* is more graceful, but it is likely to cause cracks because it has the beds and joints in every direction. The "uncertain" rough work, *opus incertum*, lying course above course and breaking joints, furnishes walling which is not pleasing but is stronger than the *reticulatum*. 2. Both kinds of walling are to be built with very minute stones; so that the walls, thoroughly saturated with mortar of lime and sand, may hold longer together. For since the stones are of a soft and open nature, they dry up the moisture by sucking it out of the mortar. But when the supply of lime and sand is abundant, the wall having more moisture will not quickly become

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umoris non cito fiet evanidus, sed ab his continetur. Simul autem umida potestas e materia per caementorum raritatem fuerit exsucta¹ calxque ab harena discedat et dissolvatur, item caementa non possunt cum his cohaerere, sed in vetustatem parietes efficiunt ruinosos.² Id autem licet animadvertere etiam de nonnullis monumentis, quae circa urbem facta sunt e marmore seu lapidibus quadratis intrinsecusque medio calcata: structuris vetustate evanida facta materia caementorumque exstructa raritate, proruunt et coagmentorum ab ruina dissolutis iuncturis dissipantur. Quodsi qui noluerit in id vitium incidere, medio cavo servato secundum orthostatas³ intrinsecus ex rubro⁴ saxo quadrato aut ex testa aut ex silicibus ordinariis struat bipedales parietes, et cum his ansis ferreis et plumbo frontes vinctae sint. Ita enim non acervatim,⁵ sed ordine structum opus poterit esse sine vitio sempiternum, quod cubilia et coagmenta eorum inter se sedentia et iuncturis alligata non protrudent opus neque orthostatas inter se religatos labi patiuntur.

5 Itaque non est contemnenda Graecorum structura; utuntur e molli caemento polita, sed cum discesserunt a quadrato, ponunt de silice seu lapide duro ordinaria, et ita uti latericia struentes alligant eorum alternis

¹ exsucta *rec*: exsuta *H*.

² ruinosos *H*: rimosos *G*.

³ orchostatas *H*.

⁴ robro *H*.

⁵ acervatim *rec*: acervati *H*.

¹ The tombs outside Rome along the Appian Way furnished examples by which intending builders could judge the durability of materials.

BOOK II. c. VIII.

perishable, but holds together. When once, also, the moist power has been sucked out of the mortar, through the loose structure of the rubble, and the lime separates from the sand and is dissolved, the rubble also cannot cohere with them, but renders the walls ruinous with lapse of time. 3. This we may observe from some tombs which are built near ¹ the city, faced with marble or squared stone, and, in the interior, constructed with walling material pressed down. The mortar becomes perishable in time and is drawn out through the loose joints of the rubble. Hence the tombs collapse and disappear when the union of the joints is broken by settlement. 4. But if anyone does not wish to fall into this fault, let him keep the middle hollow behind the facings, and, on the inside, build walls two feet thick of red square stone ² or of baked brick ³ or of lava,⁴ laid in proper courses, and let the facings be tied to these by iron clamps ⁵ run in with lead. For thus the work is not built all of a heap but in order, and can last; because the beds and joints settling together and bound by ties do not thrust the work forward nor allow the facings bound in this way to give.

5. Therefore the walling of the Greeks is not to be made light of. For they do not employ walling of soft rubble with stucco facing, but when they depart from ashlar,⁶ they lay courses of lava or hard stone, and, as with brick buildings, they bind their joints in

² Tufa.

³ *testa*—note the gradual improvement in building methods.

⁴ *silex*—c. v. l.

⁵ Re-invented by Brunelleschi. *Orthostata*, Greek word for Latin *frons* = facing. Vitruvius probably used Greek as his vernacular.

⁶ Squared stones.

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coriis coagmenta, et sic maxime ad aeternitatem firmas perficiunt virtutes. Haec autem duobus generibus struuntur; ex his unum isodomum,¹
 6 alterum pseudisodomum² appellatur. Isodomum dicitur, cum omnia coria aequa crassitudine fuerint structa; pseudisodomum, cum inpaes et inaequales ordines coriorum diriguntur. Ea utraque sunt ideo firma, primum quod ipsa caementa sunt spissa et solida proprietate neque de materia possunt exsugere liquorem, sed conservant ea in suo umore ad summam vetustatem; ipsaque eorum cubilia primum plana et librata posita non patiuntur ruere materiam, sed perpetua parietum crassitudine religata continent
 7 ad summam vetustatem. Altera est quam *enplecton*³ appellant, qua etiam nostri rustici utuntur. Quorum⁴ frontes poliuntur, reliqua ita, uti sunt nata, cum materia conlocata alternis alligant coagmentis. Sed nostri celeritati studentes, erecta conlocantes frontibus serviunt et in medio faciunt fractis⁵ separatim cum materia caementis. Ita tres suscitantur in ea structura crustae, duae frontium et una media farturae. Graeci vero non ita, sed plana conlocantes et longitudines eorum alternis in crassitudinem instruunt, non media farciunt, sed e suis frontatis perpetuam et unam⁶ crassitudinem parietum consolidant. Prae caetera interponunt singulos crassi-

¹ hisodomum *H.*

² speudisodomum *H.*

³ enplecton *H.*

⁴ quorum *i. marg. suppl. S^e.*

⁵ fractis *Joc: factis H.*

⁶ et unam *Schn: et in unam H.*

¹ That is, with "bond"; cf. English and Flemish bond in modern brickwork. In English bond, there are alternate courses of headers and stretchers; in Flemish, headers and

BOOK II. C. VIII.

alternate courses,¹ and so they produce strength firm enough to last. Well, these are built in two kinds. Of these one is called *isodomum*, the other is called *pseudisodomum*. 6. It is called *isodomum* when all the courses are built of an equal thickness; *pseudisodomum* when the courses are unequal and unlike. Both are firm, for the reason especially that the rubble itself is of a thick and solid property, and cannot suck out the moisture from the mortar; the rubble preserves the mortar with its moisture for a long time; and the bed-joints of the stone, being laid flat and levelled, do not allow the mortar to sink down; but the stones being bonded in the unbroken thickness of the walls, keep the mortar together for a long time. 7. The second is that which they call *enplecton*, which our country people still use. In this the faces are dressed²; the rest of the stones are laid with mortar in their natural state, and they bond them with alternating joints. But people nowadays, being eager for speedy building, attend only to the facing, setting the stones on end, and fill it up in the middle with broken rubble and mortar.³ Thus three slices are raised in this walling, two of the facings, and a middle one of the filling in. Not so the Greeks who lay the stones level and put the headers and stretchers alternately. Thus they have not to fill in the middle, but with their through facing stones they render solid the unbroken and single thickness of the walls. In addition to the rest, they insert special stones

stretchers alternate in the same course. Hence the joints in the course above do not come over the joints in the course below.

² *columnae politae sunt.* Cic. *Q. Fr.* III. i. 1.

³ *materia*, cementing material.

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tudine perpetua utraque parte¹ frontatos, quos *diatonous*² appellant, qui maxime religando confirmant parietum soliditatem.

- 8 Itaque si qui voluerit ex his commentariis animadvertere et elegere genus structurae, perpetuitatis poterit rationem habere. Non enim quae sunt e molli caemento subtili facie venustatis, non eae possunt esse in vetustate³ non ruinosae. Itaque cum arbitrio⁴ communium parietum sumuntur, non aestimant eos quanti facti fuerint, sed cum ex tabulis inveniunt eorum locationes, pretia praeteritorum annorum singulorum deducunt octogesimas et ita—ex reliqua summa parte reddi pro his parietibus—sententiam pronuntiant eos non posse plus quam
9 annos LXXX durare. De latericiis vero, dummodo ad perpendicularum sint stantes, nihil deducitur, sed quanti fuerint olim facti, tanti esse semper aestimantur. Itaque nonnullis civitatibus et publica opera et privatas domos etiam regias a latere structas licet videre: et primum Athenis murum, qui spectat ad Hymettum⁵ montem et Pentelensem; ⁶ item Patris⁷ in aede Iovis et Herculis latericias cellas, cum circa lapideae in aede epistylia sint et columnae; in Italia

¹ partes *H.*

² diatonos *H.*

³ vetustate *h*: venustate *H.*

⁴ arbitri *Polenus*: arbitrio *H.*

⁵ hymectiū *H.*

⁶ tentelensem *H.*

⁷ item Patris *Gal*: item paries *H.*

¹ For building laws: see I. i. 10.

² This could only come in when the improved methods of brick building were established under the empire.

³ Unbaked bricks were used in Greece until the time of Alexander.

⁴ To the east.

⁵ To the north.

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facing on either front of unbroken thickness. These they call *diatonos* (through-stones), and they, by bonding, especially strengthen the solidity of the wall.

8. Therefore if anyone will from these commentaries observe and select a style of walling, he will be able to take account of durability. For those which are of soft rubble with a thin and pleasing facing cannot fail to give way with lapse of time. Therefore when arbitrators¹ are taken for party-walls, they do not value them at the price at which they were made, but when from the accounts they find the tenders for them, they deduct as price of the passing of each year the 80th part, and so—in that from the remaining sum repayment is made for these walls—they pronounce the opinion that the walls cannot last more than 80 years. 9. There is no deduction² made from the value of brick walls provided that they remain plumb; but they are always valued at as much as they were built for. Therefore in some cities we may see both public works and private houses and even palaces built of brick:³ and first, the wall at Athens which looks to Mount Hymettus⁴ and Pentelicus⁵; also at Patrae,⁶ brick cellae in the temple of Jupiter⁷ and Hercules, while round the temple there are entablatures and columns of stone; in Italy at Arezzo⁸ there is an old

⁶ Augustus made this a colony. It became the chief city of the Peloponnese. "It was the most Roman town in Greece." Tyrrell and Purser, *ad* Cic. *Epp.* 512. 1.

⁷ There was a temple of Olympian Jupiter (Zeus) in the forum, Paus. VII. 20. 2.

⁸ Arezzo was the chief source of the *terra sigillata*, red "Samian" ware. Oswald and Pryce's *Terra Sigillata* may be consulted with advantage. The technical process of making this ware has been rediscovered. Neuburger, 147.

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- Arretio vetustum egregie factum murum. Tralibus¹ domus regibus Attalicis facta, quae ad habitandum semper datur ei, qui civitatis gerit sacerdotium. Item Lacedaemone e quibusdam parietibus etiam picturae excisae intersectis lateribus inclusae sunt in ligneis formis et in comitium ad ornatum aedilitatis
- 10 Varronis et Murenæ fuerunt adlatae. Croesi domus, quam Sardiani civibus ad requiescendum aetatis otio seniorum collegio gerusiam dedicaverunt; item Halicarnasso potentissimi² regis Mausoli domus, cum Proconnensio marmore omnia haberet ornata, parietes habet latere structos, qui ad hoc tempus egregiam praestant firmitatem ita tectoriis operibus expoliti, uti vitri perluciditatem videantur habere. Neque is rex ab inopia id fecit; in infinitis enim vectigalibus erat fartus, quod imperabat Cariae toti.
- 11 Acumen autem eius et sollertiam ad aedificia paranda sic licet considerare. Cum esset enim natus Mylasis³ et animadvertisset Halicarnasso locum naturaliter esse munitum, emporiumque idoneum portum utile, ibi sibi domum constituit. Is autem

¹ tralibus *H.* ² alicarnasso *H.* potentissimae *H.*

³ mylasis *H^c G:* mylasus *H G^c.*

⁴ locum *G:* loco cum *H.*

¹ In Asia Minor, S. of Ionia.

² The kings of Pergamus.

³ The Priest of the City was the chief magistrate. He was usually called Asiarch, *Acts* xix. 31.

⁴ Frescoes on the brickwork.

⁵ Ancient meeting-place of citizens, N.E. of forum.

Murena was probably aedile 68 B.C. with Varro, the famous scholar.

⁶ King of Lydia 560-546 B.C.

⁷ Sardis: a fourth-century B.C. temple of Artemis was excavated 1910-1912; stamped brick with winged Artemis probably contemporary with Croesus, *J.H.S.* XXIX. 299.

BOOK II. c. VIII.

brick wall excellently built. At Tralles¹ there is a palace built for the Attalid kings,² which now is always given for a house to him who is the Priest of the City³: also at Lacedaemon the bricks were cut through from certain walls, the paintings⁴ were removed and enclosed in wooden frames, and brought into the Comitium⁵ as an ornament for the aedileship of Varro and Murena. 10. There is the palace of Croesus,⁶ which the people of Sardis⁷ dedicated to their fellow-citizens for repose in the leisure of their age, as an Almshouse⁸ for the College of the Elders. At Halicarnassus⁹ also, although the palace of the mighty king Mausolus¹⁰ had all parts finished with Proconnesian¹¹ marble, it has walls built of brick.¹² And these to this day maintain a striking firmness, being so finished with plaster work that they seem to have the translucency of glass. Nor was it for lack of means that the king did this. For he was enriched by enormous revenues because he ruled over all Caria. 11. We may thus consider his shrewdness and skill in providing buildings. For although he was born at Melisso,¹³ he observed at Halicarnassus a place naturally fortified, a suitable market, and a useful harbour, and he there established his palace.¹⁴ Now

⁸ Lat. *senaculum*. Festus, s.v.

⁹ Over against Cos, on the mainland; excavated by Sir Charles Newton 1852-1858. The remains are in the British Museum.

¹⁰ Mausolus, King of Caria, 377-353 B.C. Vitruvius' description of his monument guided the excavations of Newton.

¹¹ Black and white marble from island of Marmora (hence its name). It was used largely at Ravenna under the Empire.

¹² Baked brick was found at Halicarnassus.

¹³ Mylasa, north of Halicarnassus, old capital of Caria.

¹⁴ Newton, *Plans and Discoveries*, Vol. II. Pl. I.

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locus est theatri curvaturae similis. Itaque in imo secundum portum forum est constitutum; per mediam autem altitudinis curvaturam praecinctionemque platea ampla latitudine facta, in qua media Mausoleum ita egregiis operibus est factum, ut in septem spectaculis nominetur. In summa arce media Martis fanum habens statuam colossicam *acrolithon* nobili manu Leocharis¹ factam. Hanc autem statuam alii Leocharis, alii Timothei putant esse. In cornu autem summo dextro Veneris et Mercuri² 12 fanum ad ipsum Salmacidis fontem. Is autem falsa opinione putatur venerio morbo implicare eos, qui ex eo biberint. Sed haec opinio quare per orbem terrae falso rumore³ sit pervagata, non pigebit exponere. Non enim quod dicitur molles et inpudicos ex ea aqua fieri, id potest esse, sed est eius fontis potestas perlucida saporque egregius. Cum autem Melas et Areuanias ab Argis et Troezen⁴ coloniam communem eo loci deduxerunt, barbaros Caras et Lelegas eiecerunt.⁵ Hi autem ad montes fugati inter se

¹ Leocharis *Rode*: telocharis *H.* ² mercuri *H.*

³ falso rumore *Joc*: falsorum ore *H.*

⁴ Troezen *Joc*: troezen *H.* ⁵ eiecerunt *II G.*

¹ Literally: "about the middle of the curvature of the height."

² Sculpture in B.M.

³ *Spectacula*: usually the Pyramids; the Gardens of Babylon; the Temple of Diana (Artemis) at Ephesus; Phidias' statue of Jupiter (Zeus) at Olympia; the Colossus of Rhodes; the Pharos (lighthouse) of Alexandria; the Mausoleum.

⁴ Newton, *op. cit.*, II. 137.

⁵ *Ibid.*, II. 141.

⁶ *acrolithon*: i.e. a herm with head, hands, feet of marble.

⁷ Leochares carved a bust, it is said, of the youthful Alexander. There is a fine copy of his Ganymede in the Vatican. He carved the sculptures on the west side of the Mausoleum.

BOOK II. C. VIII.

that place is like the curvature of a theatre. The forum is placed at the lowest level along the harbour. But about the middle of the natural amphitheatre¹ and, as it were, in a cross gangway, a street is constructed of ample width, in the middle of which the Mausoleum² is built of such splendid workmanship that it is named among the Seven Sights of the world.³ In the middle of the top of the citadel⁴ is a temple of Mars⁵ having a statue of a colossus with marble extremities⁶ made by the famous hand of Leochares.⁷ This statue some think is by Leochares, others by Timotheus.⁸ On the right wing at the top is a temple of Venus and Mercury⁹ against Salmacis'¹⁰ fountain itself. 12. This fountain, however, by a mistaken opinion, is thought to afflict with an aphrodisiac disease¹¹ those who drink of it. And why this opinion has wandered over the world through mistaken rumour it will not be inconvenient to set forth. For this cannot be because, as it is said, people are made effeminate and shameless by that water; the virtue of the spring is clearness and its flavour is excellent. Now when Melas and Arevanias led thither a joint colony from Argos and Troezen, they cast out the barbarians, Carians and Leleges. But these being driven to the hills, gathered together

⁸ Timotheus carved the sculpture on the south side of the Mausoleum.

⁹ Newton found no traces of this temple, II. 144.

¹⁰ The native town of Salmacis adjoined Halicarnassus. The two towns had one assembly, but their several magistrates for each town. Newton found no fountain answering to the description in the text. Dittenberger, *Sylloge*, 5. The main street runs east and west.

¹¹ Vitruvius' scientific attitude to medicine renders this reference noteworthy.

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congregantes discurrerant et ibi latrocinia facientes crudeliter eos vastabant. Postea de colonis unus ad eum fontem propter bonitatem aquae quaestus causa tabernam omnibus copiis instruxit eamque exercendo eos barbaros allectabat. Ita singillatim decurrentes et ad coetus convenientes e duro ferroque¹ more commutati in Graecorum consuetudinem et suavitatem sua voluntate reducebantur. Ergo ea aqua non inpudico morbi vitio, sed humanitatis dulcedine mollitis animis barbarorum eam famam est adepta.

- 13 Relinquitur nunc, quoniam ad explicationem moenium eorum sum inductus, totam² uti sunt definitionem. Quemadmodum enim in dextra parte fanum est Veneris et fons supra scriptus, ita in sinistro cornu regia domus, quam rex Mausolus³ ad suam rationem conlocavit. Conspicitur enim ex ea ad dextram partem forum et portus moeniumque⁴ tota finitio, sub sinistram secretus sub montibus⁵ latens portus, ita ut nemo posset, quid in eo geratur, aspicere nec scire, ut rex ipse de sua domo remigibus et militibus sine ullo sciente quae opus essent, spectaret.⁶ Itaque post mortem Mausoli Artemisiam uxorem eius regnantem Rhodii indignantes mulierem imperare civitatibus Cariae totius, armata classe profecti sunt, uti id regnum occuparent. Tum Artemisiae cum esset id renuntiatum, in eo portu

¹ ferroque *H.*

² tota *G*: totâ *H G*.

³ manu solus *H.*

⁴ portus *H*^e *S*: portum *H G*.

⁵ moenibus *Ross (rec)*: montibus *H*.

⁶ spectaret *e*, *Sulp*: spirarent *H G*.

¹ *Si ager secundum viam et opportunus viatoribus locus, aedificandae tabernae diversoriae.* Varro, *R.R.* I. ii. 23.

BOOK II. c. VIII.

and made raids, and by brigandage they devastated the Greeks cruelly. But afterwards one of the colonists,¹ for the sake of profit, fitted up an inn with complete supplies, near the spring, on account of the goodness of the water, and running the inn, he began to attract the barbarians. So coming down one by one, and mixing with society, they changed of their own accord from their rough and wild habits to Greek customs and affability. Therefore this water obtained such a reputation, not by the plague of an immodest disease, but through the softening of savage breasts by the delights of civilisation.

13. Since now I am brought to the description of these walls,² it remains to outline it completely as they are. For just as on the right side there are the temple of Venus and the spring above described, so on the left wing is the royal palace which King Mausolus had built to his own plan. From it there is seen on the right side the forum and harbour and the whole circuit of the walls; under the left there is a secret harbour lying hid under high ground, in such a way that no one can see or know what is going on in it, so that the king from his own palace could see³ what was necessary for his sailors and soldiers, without anyone else knowing. 14. Therefore when, after the death of Mausolus, his wife Artemisia⁴ began to reign, the Rhodians were indignant that a woman should rule over the cities throughout Caria, and equipping a fleet they set out to seize the kingdom. It was reported to Artemisia. She hid the

² Mention is made of a brick wall. Arrian, *Anabasis*, I. xxii. 1.

³ The reading in the text is an emendation made in a late MS.

⁴ Artemisia, sister and wife of Mausolus, reigned 353-350 B.C.

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- abstrusam classem celatis remigibus et epibatis comparatis, reliquos autem cives in muro esse iussit. Cum autem Rhodii ornata classe in portum maiorem exposuissent, plausum iussit ab muro his darent¹ pollicerique se oppidum tradituros. Qui cum penetravissent intra murum relictis navibus inanibus, Artemisia repente fossa facta in pelagum eduxit classem ex portu minore et ita invecta est in maiorem. Expositis autem militibus classem Rhodiorum inanem abduxit in altum. Ita Rhodii non habentes, quo se reciperent, in medio conclusi in ipso foro sunt
- 15 trucidati. Ita Artemisia in navibus Rhodiorum suis militibus et remigibus inpositis Rhodum est profecta. Rhodii autem, cum prospexissent suas naves laureatas venire, opinantes cives victores reverti hostes receperunt. Tum Artemisia Rhodo capta principibus occisis tropaeum in urbem Rhodo suae victoriae constituit aeneasque duas statuas fecit, unam Rhodiorum civitatis, alteram suae imaginis, et ita figuravit Rhodiorum civitati stigmata inponentem. Id autem postea Rhodii religione inpediti, quod nefas est tropaea dedicata removeri, circa eum locum aedificium struxerunt et id erecta Graia statione texerunt, ne qui possit aspicere, et id *abaton* vocitari iusserunt.
- 16 Cum ergo tam magna potentia reges³ non contempserint latericiorum parietum structuram, quibus et vectigalibus et praeda saepius licitum fuerat non modo caementicio aut quadrato saxo sed etiam

¹ dare *G* : darent *H*.

² abathon.

³ reges *Joc* : regis.

¹ Mark set upon slaves.

² Plut. *Rom. Q.* 37.

³ *statio*, a guardhouse.

BOOK II. c. viii.

fleet in the harbour, concealing the rowers and the marines she had got together, and ordered the rest of the citizens to man the walls. Now when the Rhodians had landed, with a fleet well equipped, in the greater harbour, she commanded the citizens to greet them from the walls and to promise to surrender the town. These left their ships unmanned and penetrated within the wall. Artemisia, using an artificial outlet into the sea, suddenly led out her fleet from the lesser harbour and thus sailed into the greater. She then landed her soldiers and took the empty Rhodian fleet away to sea. So the Rhodians, having no place of retreat, were surrounded and killed in the forum itself. 15. So Artemisia, placing her own troops and rowers in the ships of the Rhodians sailed for Rhodes. But when the Rhodians saw their own ships come wreathed with laurel, they thought their fellow-citizens returned victorious and let the enemy in. Then Artemisia took Rhodes, killed the leading citizens, and set up a trophy of her victory in the city of Rhodes, having two bronze statues made, one of the city of Rhodes, the other in her own likeness. She had the latter figured as setting a brand¹ upon the city of Rhodes. But afterwards the Rhodians, being restrained by a religious scruple because it is forbidden for trophies once dedicated to be removed,² erected a building round the spot and protected it with a Greek outpost³ to prevent anyone seeing, and ordered this to be called "unapproachable" (*abatōn*).

16. Since, therefore, kings of very great power have not disdained walls built of brick (in cases where wealth gained by taxation and plunder allowed the use not only of rubble or squared stone, but even

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marmoreo habere, non puto oportere inprobare quae sunt e latericia structura facta aedificia, dummodo recte sint tecta. Sed id genus quid ita populo Romano in urbe fieri non oporteat, exponam, quaeque sunt eius rei causae et rationes, non praetermittam.

- 17 Leges publicae non patiuntur maiores crassitudines quam sesquipedales constitui loco communi; ceteri autem parietes, ne spatia angustiora fierent, eadem crassitudine conlocantur. Latericii vero, nisi diplinthii aut triplinthii fuerint, sesquipedali crassitudine non possunt plus ¹ unam sustinere contignationem. In ea autem maiestate urbis et civium infinita frequentia innumerabiles habitationes opus est explicare. Ergo cum recipere non possit ² area planata tantam multitudinem ad habitandum in urbe, ad auxilium altitudinis aedificiorum res ipsa coegit devenire. Itaque pilis lapideis structuris testaceis, parietibus caementiciis ³ altitudines ⁴ exstructae contignationibus crebris coaxatae cenaculorum ad summas utilitates perficiunt despectationes. Ergo moenibus e contignationibus variis alto spatio multiplicatis populus Romanus egregias habet sine impeditione habitationes.
- 18 Quoniam ergo explicata ratio est, quid ita in urbe propter necessitatem angustiarum non patiuntur esse latericios parietes, cum extra urbem opus erit his uti, sine vitiiis ad vetustatem, sic erit faciendum. Summis parietibus structura testacea sub

¹ plus quam unam *G*: plus unam *H*.

² possint *Kr*: possunt.

³ caementaciis *H*.

⁴ altitudinis *H*.

¹ Plin. *N.H.* XXXV. 173. This refers to sun-dried bricks, *lateres*.

BOOK II. C. VIII.

of marble), I do not think that buildings which are made of brick walls are to be disregarded so long as they are duly roofed. But why this fashion ought not to be followed out by the Roman people in the city I will set forth, and will not omit the causes and reasons of this. 17. Public statutes do not allow a thickness of more than a foot and a half to be used for party walls. But other walls also are put up of the same thickness lest the space be too much narrowed. Now brick walls of a foot and a half—not being two or three bricks thick—cannot sustain more than one story.¹ Yet with this greatness of the city and the unlimited crowding of citizens, it is necessary to provide very numerous dwellings. Therefore since a level site could not receive such a multitude to dwell in the city, circumstances themselves have compelled the resort to raising the height of buildings. And so by means of stone pillars, walls of burnt brick, party walls of rubble, towers² have been raised, and these being joined together by frequent board floors produce upper stories with fine views over the city to the utmost advantage. Therefore walls are raised to a great height through various stories, and the Roman people has excellent dwellings without hindrance.

18. Now, therefore, the reason is explained why, because of the limited space in the city, they do not allow walls to be of sun-dried bricks. When it shall be necessary to use them, outside the city, such walls will be sound and durable after the following manner. At the top of the walls let

¹ These blocks of tenements were five and six stories high. Augustus limited the height to 70 feet.

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tegula subiciatur altitudine circiter sesquipedali habeatque proiecturas coronarum. Ita vitari poterunt quae solent in his fieri vitia; cum enim in tecto tegulae fuerint fractae aut a ventis deiectae, quae possint ex imbribus aqua perpluere, non patietur lorica testacea laedi laterem, sed proiectura coronarum reiciet extra perpendicularum stillas et ea ratione servaverit integras parietum latericiorum structuras.

- 19 De ipsa autem testa, si sit optima seu vitiosa ad structuram, statim nemo potest iudicare, quod in tempestatibus et aestate in tecto cum est conlocata, tunc, si est firma, probatur; namque quae non fuerit ex creta bona aut parum erit cocta, ibi se ostendit¹ esse vitiosam gelicidiis et pruina tacta. Ergo quae non in tectis poterit pati laborem, ea non potest in structura oneri ferendo esse firma. Quare maxime ex veteribus tegulis tecta structa; parietes firmitatem poterunt habere.

- 20 Craticii² vero velim quidem ne inventi essent; quantum enim celeritate et loci laxamento prosunt, tanto maiori et communi sunt calamitati, quod ad incendia uti faces sunt parati. Itaque satius esse videtur impensa testaceorum in sumptu, quam compendio craticiorum esse in periculo. Etiamque³ in tectoriis operibus rimas in his faciunt arrectariorum et transversariorum dispositione. Cum enim linuntur, recipientes umorem turgescunt, deinde siccescendo⁴ contrahuntur et ita extenuati

¹ ostendet *G*: -dit *H*.

² graticii *H*,

³ etiamque *Schn*: etiam qui *H*.

⁴ siccescendo *H*.

¹ Wattlework, Innocent, *English Building Construction*, 70, etc.

² Fires occurred at Rome frequently. A fire brigade, *cohors vigilum*, was established A.D. 6.

BOOK II. c. VIII.

walling of burnt brick be put beneath the tiles, and let it have a projecting cornice. So the faults which usually happen here can be avoided. For when tiles in the roof are broken or thrown down by the wind (where rain-water could pass through from showers), the burnt brick shield will not allow the brickwork to be damaged; but the projection of the cornices will throw the drippings outside the facing line, and in that way will keep intact the structure of brick walls. 19. But whether the baked brick itself is very good or faulty for building, no one can judge its strength offhand, because only when it is laid as a coping is it tested by weathering and lapse of time. For brickwork that is not made of good clay or is too little baked shows its faults on the work when weathered by ice and hoar-frost. Therefore the brickwork which cannot stand the strain in the coping courses cannot be strong enough in the walling to carry loads. Wherefore the coping courses are specially built from old tiles, and the walls will be strong enough.

20. I could wish that walls of wattlework¹ had not been invented. For however advantageous they are in speed of erection and for increase of space, to that extent are they a public misfortune, because they are like torches ready for kindling.² Therefore it seems better to be at greater expense by the cost of burnt brick than to be in danger by the convenience of wattlework walls: for these also make cracks in the plaster covering owing to the arrangement of the uprights and cross-pieces. For when the plaster is applied, they take up the moisture and swell, then when they dry they contract, and so they are rendered thin, and break the

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disrumpunt tectoriorum soliditatem. Sed quoniam nonnullos celeritas aut inopia aut in pendentem loco dissaepitio cogit, sic erit faciendum.¹ Solum substruatur, ut sit intactum ab rudere et pavimento; obruta enim in his cum sunt, vetustate marcida fiunt; deinde subsidencia proclinantur et disrumpunt speciem tectoriorum.

De parietibus et apparitione generatim materiae eorum, quibus sint virtutibus et vitiis, quemadmodum potui, exposui; de contignationibus autem et copiis earum, quibus conparentur, et ad vetustatem non sint infirmae, uti natura rerum monstrat, explicabo.

IX

- 1 MATERIES caedenda est a primo autumnio ad id tempus, quod erit antequam flare incipiat favonius. Vere enim omnes arbores fiunt praegnantes et omnes suae proprietatis virtutem efferunt in frondem anniversariosque fructus. Cum ergo inanes et umidae temporum necessitate² eorum fuerint, vanae fiunt et raritatibus inbecillae; uti etiam corpora muliebria, cum conceperint, ad foetus a partu non iudicantur integra, neque in venalibus ea, cum sunt praegnantia, praestantur sana, ideo quod in corpore praeseminatio crescens ex omnibus cibi potestatibus detrahit alimentum in se, et quo firmior efficitur ad maturitatem partus, eo minus patitur esse solidum id ex

¹ faciendum *G.*

² necessitate *rec*: -tes *H.*

¹ The subject of this chapter is treated by Theophrastus, *Hist. Plant.* V. i.

BOOK II. C. VIII.—C. IX.

solidity of the plaster. But since haste, or lack of means, or partitions made over an open space, sometimes require this construction, we must proceed as follows. Let the foundation be laid high up, so that it is untouched by the rough stones of the pavement; for when they are fixed in these, they become rotten in time; then they settle, and falling forward they break through the surface of the plaster.

With respect to walls and the use of material after its kinds, I have explained their excellences and faults as I have been able. Now with respect to floors and the material from which they are provided, so that they may not be weakened by lapse of time, I will explain as nature shows.

CHAPTER IX

ON TIMBER

1. Wood ¹ is to be felled from the beginning of autumn to the time which comes before the blowing of the west wind. For in spring all trees become pregnant and discharge all the excellence of their own property into their foliage and yearly fruit. When, therefore, they are rendered empty and moist in their season, they become void and weak by their open structure. Females also, when they have conceived offspring, are not adjudged sound until delivery; and in the case of slaves, they are not guaranteed sound when they are pregnant, because the fertilisation as it spreads in the body draws nourishment to itself from the potencies of the food; and the stronger the offspring is rendered for its ripening, the less solid does it allow that to be

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quo ipsum procreatur. Itaque edito foetu, quod prius in aliud genus incrementi detrahebatur, cum a disparatione¹ procreationis est liberatum, inanibus et patentibus venis in se recipient. Lambendo sucum etiam solidescit et redit in pristinam
2 naturae firmitatem. Eadem ratione autumnali tempore maturitate fructuum flaccescente fronde, et terra recipientes radices arborum in se sucum recipiuntur et restituuntur in antiquam soliditatem. At vero aeris hiberni vis comprimit et consolidat eas per id, ut supra scriptum est, tempus. Ergo si ea ratione et eo tempore, quod est supra scriptum,
3 caeditur materies, erit tempestiva. Caedi autem ita oportet, uti incidatur arboris crassitudo ad mediam medullam, et relinquatur, uti per eam exsiccescat stillando sucus. Ita qui inest in his inutilis liquor effluens per torulum non patietur emori in eo saniem nec corrumpi² materiae aequalitatem. Tum autem, cum sicca et sine stillis erit arbor, deiciatur
4 et ita erit optima in usu. Hoc autem ita esse licet animum advertere etiam de arbustis. Ea enim cum suo quoque tempore ad imum perforata castrantur, profundunt e medullis quae habent in se superantem et vitiosum, per foramina liquorem, et ita siccescendo recipiunt in se diuturnitatem. Quae autem non habent ex arboribus exitus umoris, intra concrescentes putrescunt, et efficiunt inanes eas vitiosas. Ergo si stantes et vivae siccescendo non senescunt, sine dubio cum eae³ ad materiam deiciuntur, cum ea ratione curatae fuerint, habere poterunt magnas in aedificiis ad vetustatem utilitates.

¹ a disparatione *Perrault*: ad disperatione *H*.

² necorrumpi *H*.

³ eae (*Ro*) ad materiam *Joc*: eadem materiam *H*.

BOOK II. c. ix.

from which it is engendered. And so when the offspring is brought forth, what previously was withdrawn to another kind of growth, the body will receive into itself through the empty and open pores. By taking up juices it becomes solid, and returns to the strength of its former nature.

2. Likewise in autumn the leaves wither when the fruits are ripe. The roots of the trees receive into themselves the sap from the earth, and are recovered and restored to their old solidity. But the power of the winter air compresses and consolidates them through that time as is written above.

Therefore if the wood is cut in the manner and at the time described above, it will be in season,

3. Now it ought to be cut so that the thickness of the tree is cut to the middle of the pith, and left, that the sap may dry out by dripping. Thus the useless fluid which is in the veins flows out through the sapwood, and does not let the watery part die away in it, nor the quality of the wood to be corrupted. But when the tree is dry and does not drip, let it be cut down, and so it will be best in use.

4. This, moreover, we can perceive about shrubs also. When they are bored through at the base in their proper season and pruned, they pour forth from the pith, through the openings, the excessive and diseased fluid which they contain; and thus by drying they gain durability. But those trees which have no outlets of moisture, swell inside and rot, and are rendered hollow and diseased. Therefore, if by draining when they are standing and alive trees are saved from decay, doubtless when they are felled for timber, if they are treated in the same way, they will have great advantages in buildings for durability.

VITRUVIUS

5 Hae¹ autem inter se discrepantes et dissimiles
 habent virtutes, uti robur, ulmus, populus, cupressus,
 abies ceteraque, quae maxime in aedificiis sunt
 idonea. Namque non potest id robur quod abies,
 nec cupressus quod ulmus, nec cetera easdem habent
 inter se natura rerum similitates, sed singula genera
 principiorum proprietatibus comparata alios alii
 6 generis praestant in operibus effectus. Et primum
 abies aeris habens plurimum et ignis minimumque
 umoris et terreni, levioribus rerum naturae potestati-
 bus comparata non est ponderata.² Itaque rigore
 naturali contenta non cito flectitur ab onere, sed
 directa permanet in contignatione. Sed ea, quod
 habet in se plus caloris, procreat et alit cariem³ ab
 eaque vitiatur, etiamque ideo celeriter accenditur,
 quod quae inest in eo corpore aeris raritas et est
 patens, accipit ignem et ita vehementem ex se
 7 mittit flammam. Ex ea autem, antequam est excisa,
 quae pars est proxima terrae, per radices recipiens
 ex proximitate umorem enodis et liquida efficitur;
 quae vero est superior, vehementia caloris eductis
 in aera per nodos ramis, praecisa alte circiter pedes
 xx et perdolata propter nodationis duritiem dicitur
 esse fusterna. Ima autem, cum excisa quadrifluis
 disparatur, eiecto torulo ex eadem arbore ad intestina
 opera comparatur et ab infima fusterna⁴ sappinea
 8 vocatur. Contra vero quercus terrenis principiorum

¹ hae G: ea H S.

² ponderata H.

³ cariem ed. Fl: partem H.

⁴ et ab infima fusterna Kr: et intima fusternea H.

¹ *alii* as gen. of *alius* is found in Cic. and Varro.

² The Baltic fir of to-day runs to about 35 feet without knots.

³ The diameter is divided into four parts, and perpendiculars are set up $\frac{1}{4}$ of the diameter from either end. These intersect

BOOK II. c. ix.

5. Now trees have virtues varying and unlike one with another; for example, oak, elm, poplar, cypress, fir, and the rest which are most suitable in buildings. For the oak has not the same power as the fir, nor the cypress as the elm, nor have the rest by nature the same resemblances one with another. But the several kinds furnished with the properties of their first principles provide in the work various¹ effects. 6. And first, the fir has most air and fire and least moisture and earth. Being thus furnished with the lighter powers of Nature, it is not weighed down. It is held together by a natural stiffness, and is not quickly bent by a load, but remains straight in the flooring. But timber which has more heat generates and feeds decay and is diseased by it. Fir is also soon kindled because the rarefaction of the air which is present in this body, and is porous, receives the fire, and so sends forth a vehement flame. 7. Of the tree before it is cut down, the part which is nearest the earth receives the moisture from the neighbourhood through the roots and is rendered free from knots and moist. The upper part (since by the vehemence of the heat the branches are carried into the air through the knots) is cut off about twenty feet up.² It is rough-axed and because of the hardness of the knotted portion is called "knotwood." The lowest portion, however, when it is cut and divided in four directions,³ and the sapwood⁴ is rejected from the same tree, is used for inside work, and is called "deal." 8. The oak (*quercus robur*), on the other hand, abounds

the circumference, and lines are drawn to both ends of the diameter so as to form a rectangle, *Builder's Work*, 137.

⁴ The sapwood is the outside ring of soft wood.

VITRUVIUS

satietatibus abundans parumque habens umoris et aeris et ignis, cum in terrenis operibus obruitur, infinitam habet aeternitatem. Ex eo cum tangitur umore, non habens foraminum raritates propter spissitatem non potest in corpus recipere liquorem, sed fugiens ab umore resistit et torquetur et efficit, 9 in quibus est operibus, ea rimosa. Aesculus vero, quod est omnibus principiis temperata, habet in aedificiis magnas utilitates; sed ea, cum in umore conlocatur, recipiens penitus per foramina liquorem eiecto aere et igni operatione umidae potestatis vitatur. Cerrus quercus fagus, quod pariter habent mixtionem umoris et ignis et terreni, aeris plurimum, provisa¹ raritates umoris penitus recipiendo celeriter marcescunt. Populus alba et nigra, item salix, tilia vitex ignis et aeris habendo satietatem, umoris temperate, parum autem terreni habens² levioere temperatura comparata, egregiam habere videtur in usu rigiditatem. Ergo cum non sint dura terreni mixtione propter raritatem sunt candida et in sculp- 10 turis commodam praestant tractabilitatem. Alnus autem, quae proxima fluminum ripis procreatur et minime materies utilis videtur, habet in se egregias rationes. Etenim aere et igni plurimo temperata, non multum terreno, umore paulo. Itaque in palustribus³

¹ *puisa* *H*: provisa *Gr*.

² *habentes* *H*: habens *Gr*.

³ itaque in palustribus *Schn*.: itaque non minus habent in corpore umoris in plaustribus *H*.

¹ Oak lasts for indefinite periods when buried in the ground and is known as "bog oak."

² It is almost impossible to guarantee the best oak against warping.

³ *Quercus sessiliflora*, a variety of the preceding, was sacred to Jupiter and is tall.

BOOK II. c. ix.

in earthy saturations of the elements, and has little moisture and air and fire. When it is buried in foundations, it has unlimited duration.¹ Hence, when it is touched by moisture, not having open pores, it cannot because of its density admit fluids into its substance, but, shrinking from moisture, it stands and is warped ² and causes cracks in the work.

9. But the winter oak (*quercus aesculus*³), because it is blended with all the elements, has great advantages in building. Yet when it is placed in water, it admits the fluid within, through the pores, and losing air and fire is damaged by the operation of the humid potency. The Turkey oak ⁴ and the beech, because they have a mixture of the humid, the fiery and the earthy, and an excess of air, being furnished with open pores, admit moisture and quickly decay. The white and black poplar, the willow also, the lime, the agnus castus,⁵ having the fire and air to saturation, the humid in moderation, too little of the earthy, are composed of a lighter mixture, and seem to have unusual firmness in use. Although, therefore, they are not hard owing to the mixture of the earthy, they are rendered white by their porous structure and are convenient to handle in the case of carving. 10. But the alder, which grows next the banks of rivers, and seems a useless timber, has nevertheless some remarkable applications. For it is blended with much air and fire, not much earth, little of the humid. And so frequently

⁴ The Turkey oak grows more quickly, but does not produce such good timber.

⁵ A tall tree, like the willow.

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- locis infra fundamenta aedificiorum palationibus crebre fixa, recipiens in se quod minus habet in corpore liquoris, permanet immortalis ad aeternitatem et sustinet inmania pondera structurae et sine vitiis conservat. Ita quae¹ non potest extra terram paulum tempus durare, ea in umore obruta per-
- 11 manet ad diuturnitatem. Est autem maximum id considerare Ravennae, quod ibi omnia opera et publica et privata sub fundamentis eius generis habeant palos. Ulmus vero et fraxinus maximos habent umoris minimumque aeris et ignis, terreni temperate mixtione comparatae. Sunt in operibus, cum fabricantur, lentae et ab pondere umoris non habent rigorem et celeriter pandant; simul autem vetustate sunt aridae factae aut in agro perfecto qui est eis liquor stantes emoriuntur, fiunt duriores et in commissuris et coagmentationibus ab lentitudine
- 12 firmas recipiunt catenationes. Item carpinus, quod est minima ignis et terreni mixtione, aeris autem et umoris summa continetur temperatura, non est fragilis, sed habet utilissimam tractabilitatem. Itaque Graeci, quod ex ea materia iuga iumentis comparant, quod apud eos iuga *zyga* vocitantur, item *zygian* eam² appellant. Non minus est admirandum de cupresso et pinu, quod eae habentes umoris abundantiam aequamque ceterorum mixtionem, propter umoris satietatem in operibus solent esse pandae, sed in vetustatem sine vitiis conservantur, quod is liquor, qui inest penitus in corporibus earum, habet amarum saporem qui propter acri-

¹ itaq, *H* (*corr. Joc.*) ² *Zyγαν* eam *Joc* : *zigaeam H.*

¹ In modern times usually replaced by concrete.

² The alternative name "yoke-elm" is parallel to the Greek.

BOOK II. C. IX.

alder stakes, being fixed in marshy ground below the foundations of buildings, admit fluid because they have a less quantity in their substance. Hence they remain imperishable to eternity, uphold immense weights of walling, and preserve them without decaying. Thus a timber which cannot endure even a short time above ground, when it is buried in moisture abides for long periods. 11. Now we can best consider this at Ravenna; because there all works both public and private have piles ¹ of this kind under their foundations. But the elm and the ash have an excess of moisture, very little air and fire, and are provided moderately with a mixture of the earthy. When they are wrought for buildings they are pliant, and, owing to the weight of moisture, they are without stiffness and quickly bend. In time, however, they become dried up, or the moisture which is in them being cast forth, they are allowed to die off, standing in the open. At the same time they become harder, and owing to their pliability they make good joints, both upright and horizontal. 12. The hornbeam ² has a slight mixture of fire and earth, and is compounded with a full supply of air and moisture; it is not fragile, but is most convenient to handle. And so the Greeks, because they prepare yokes for cattle from this wood, and because among them yokes are called *zyga*, also call it *zygia*. There is not less cause for wonder in the cypress and the pine. They have abundance of moisture, equal to the whole mixture of the rest. Because of their saturation with moisture, they usually warp in use, but they last for a long time without decay. For the moisture which is within the timber has a bitter

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- itudinem non patitur penetrare cariem neque eas bestiolas quae sunt nocentes. Ideoque quae ex his generibus opera constituuntur, permanent ad aeternam diuturnitatem. Item cedrus et iuniperus easdem habent virtutes et utilitates; sed quemadmodum ex cupressu et pinu resina, ex cedro oleum quod cedrium¹ dicitur, nascitur, quo reliquae res cum² sunt unctae, uti etiam libri, a tineis et carie non laeduntur. Arboris³ autem eius sunt similes cupresseae foliaturae; materies vena directa. Ephesi⁴ in aede simulacrum Dianae ex ea,⁵ lacunaria et ibi et in ceteris nobilibus fanis propter aeternitatem sunt facta. Nascuntur autem eae arbores maxime Cretae et Africae et nonnullis Syriae regionibus. Larix vero, qui non est notus nisi is municipalibus qui sunt circa ripam fluminis Padi et litora maris Hadriani, non solum ab suco vehemente amaritate ab carie aut tineas non nocetur, sed etiam flammam ex igni non recipit, nec ipse per se potest ardere, nisi uti saxum in fornace ad calcem coquendam aliis lignis uratur; nec tamen tunc flammam recipit nec carbonem remittit, sed longo spatio tarde comburitur. Quod est minima ignis et aeris e principiis temperatura, umore autem et terreno est spisse solidata, non habet spatia foraminum, qua possit ignis penetrare, reicitque eius vim nec patitur ab eo sibi cito noceri, propterque pondus ab aqua

¹ cedrium *Plin.* 16, 52 : cidreum *H.*

² corelique res cum *H.*

³ arboris *Phil.* : -res *H.*

⁴ aephesi *H.*

⁵ ex ea *Kr.* : etiam *H.*

¹ The paper received a yellow tinge. Papyrus began to be replaced at Rome by vellum at the end of the republic.

BOOK II. c. ix.

flavour. Because of its bitterness it prevents the entrance of decay and of those small creatures which are injurious. And so the works which are executed from these kinds of trees endure an unlimited time. 13. Cedar and juniper, also, have the same virtues and advantages. Just as resin comes from cypress and pine, so from cedar comes the oil which is called oil of cedar. When other things, as, for example, books, are soaked with this,¹ they escape injury from worms and dry rot. The tree is like the cypress in foliage; the wood is of a straight vein. In the temple at Ephesus, the image of Diana, the coffers of the ceiling also, are made of these trees²—as also in other famous temples—because of their durability. Now these trees are found especially in the regions of Crete and Africa and parts of Syria. 14. The larch is known only to the provincials on the banks of the river Po and the shores of the Adriatic Sea. Owing to the fierce bitterness of its sap, it is not injured by dry rot or the worm. Further, it does not admit flame from fire, nor can it burn of itself; only along with other timber it may burn stone in the kiln for making lime. Nor even then does it admit flame or produce charcoal, but is slowly consumed over a long interval. For there is the least admixture of fire and air, while the moist and the earthy principles are closely compressed. It has no open pores by which the fire can penetrate, and repels its force and prevents injury being quickly done to itself by fire. Because of its weight it is not sus-

² Cedar was largely used in Solomon's temple. Another authority affirms that the image of Diana was of ebony. *Plin. N.H.* XVI. 213.

non sustinetur, sed cum portatur, aut in navibus aut supra abiernas rates conlocatur.

- 15 Ea autem materies quemadmodum sit inventa, est causa cognoscere. Divus Caesar cum exercitum habuisset circa Alpes imperavissetque municipiis praestare commeatus, ibique esset castellum munitum, quod vocaretur Larignum, tunc, qui in eo fuerunt, naturali munitione confisi noluerunt imperio parere. Itaque imperator copias iussit admoveri. erat autem ante eius castelli portam turris ex hac materia alternis trabibus transversis uti pyra inter se composita alte, uti posset¹ de summo sudibus et lapidibus accedentes repellere. Tunc vero cum animadversum est alia eos tela praeter sudes non habere neque posse longius a muro propter pondus iaculari, imperatum est fasciculos ex virgis alligatos et faces ardentes ad eam munitionem accedentes
- 16 mittere. Itaque celeriter milites congesserunt. Posteaquam flamma circa illam materiam virgas comprehendisset, ad caelum sublata² efficit opinionem, uti videretur iam tota moles concidisse. Cum autem ea per se extincta esset et re queta turris intacta apparuisset, admirans Caesar iussit extra telorum missionem eos circumvallari. Itaque timore coacti oppidani cum se dedidissent, quaesitum, unde essent ea ligna quae ab igni non laederentur. Tunc ei demonstraverunt eas arbores, quarum in his locis maximae sunt copiae. Et ideo id castellum Larignum, item materies larigna est appellata. Haec autem per

¹ possent *Lor* : posset *H*.

² sublata *G* : -tam *H*.

¹ This seems to have been based on direct observation.

² The provincial war tax, *annona militaris*, usually in kind.

BOOK II. c. ix.

tained by water ; but when it is carried, it is placed on board ship, or on pine rafts.

15. We have reason to inquire how this timber was discovered.¹ After the late emperor Caesar had brought his forces into the neighbourhood of the Alps, and had commanded the municipalities to furnish supplies,² he found there a fortified stronghold which was called Larignum. But the occupants trusted to the natural strength of the place and refused obedience. The emperor therefore commanded his forces to be brought up. Now before the gate of the stronghold there stood a tower of this wood with alternate cross-beams bound together like a funeral pyre, so that it could drive back an approaching enemy by stakes and stones from the top. But when it was perceived that they had no other weapons but stakes, and because of their weight they could not throw them far from the wall, the order was given to approach, and to throw bundles of twigs and burning torches against the fort. And the troops quickly heaped them up. 16. The flame seizing the twigs around the wood, rose skyward and made them think that the whole mass had collapsed. But when the fire had burnt itself out and subsided. and the tower appeared again intact, Caesar was surprised and ordered the town to be surrounded by a rampart outside the range of their weapons. And so the townspeople were compelled by fear to surrender. The inquiry was made where the timber came from which was unscathed by the fire. Then they showed him the trees, of which there is an abundant supply in these parts. The fort was called Laignum following the name of the larch wood.

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Padum Ravennam deportatur. In colonia Fanestri, Pisauri, Anconae reliquisque, quae sunt in ea regione, municipiis praebetur. Cuius materies si esset facultas adportationibus ad urbem, maximae haberentur in aedificiis utilitates, et si non in omne, certe tabulae in subgrundiis circum insulas si essent ex ea conlocatae, ab traiectionibus incendiorum aedificia periculo liberarentur, quod ea neque flammam nec carbonem possunt recipere nec facere
17 per se. Sunt autem eae arbores foliis similibus pini; materies earum prolixa, tractabilis ad intestinum opus non minus quam sappinea, habetque resinam liquidam mellis Attici colore, quae etiam medetur phthisicis.

De singulis generibus, quibus proprietatibus e natura rerum videantur esse comparatae quibusque procreantur rationibus, exposui. Insequitur animadversio, quid ita quae in urbe supernas dicitur abies, deterior est, quae infernas, egregios in aedificiis ad diuturnitatem praestat usus, et de his rebus, quemadmodum videantur e locorum proprietatibus habere vitia aut virtutes, uti ea sint¹ considerantibus apertiora, exponere.²

X

1. MONTIS Appennini primae radices ab Tyrrhenico mari in Alpes et in extremas Etruriae regiones oriuntur. Eius vero montis iugum se circumagens

¹ ea (*Kr*) sint *Joc*: essent *H*.

² exponere *Ro*: exponerem *H*.

¹ Probably floated down the stream on rafts of pine.

² Coupled with Pisaurum, Wilmann's *Inscr. Lat.* 1215, and Ancona, *op. cit.* 674.

BOOK II. c. ix.-c. x.

Now this is brought down the Po to Ravenna¹; there are also supplies at the Colony² of Fanum, at Pisaurum and Ancona and the municipia in that region. And if there were a provision for bringing this timber to Rome, there would be great advantages in building; and if such wood were used, not perhaps generally, but in the eaves round the building blocks, these buildings would be freed from the danger of fires spreading. For this timber can neither catch fire nor turn to charcoal, nor burn of itself. 17. Now these trees have leaves like those of the pine, the timber is tall, and for joinery work not less handy than deal. It has a liquid resin coloured like Attic honey. This is a cure for phthysical persons.

Concerning the several kinds of trees, I have set forth the properties of which they seem to be naturally composed, and the manner in which they come to grow. The inquiry follows why the pine called Highland in Rome is inferior, whereas the so-called Lowland pine furnishes striking advantages for durability in buildings. On this topic I will set forth how they seem to acquire defects or excellences from the properties of their localities, so that they may be more obvious to the inquirer.

CHAPTER X

HIGHLAND AND LOWLAND FIR

1. THE first roots of the Apennines rise from the Tyrrhenian sea towards the Alps³ and the borders of Etruria. But the ridge of the range bends

³ The Maritime Alps.

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- et media curvatura prope tangens oras maris Hadriani pertingit circumitionibus contra fretum. Itaque citerior eius curvatura quae vergit ad Etruriae Campaniaeque regiones, apricis est potestatibus; namque impetus habet perpetuos ad solis cursum. Ulterior autem, quae est proclinata ad superum mare, septentrionali regioni subiecta continetur umbrosis et opacis perpetuitatibus. Itaque quae in ea parte nascuntur arbores, umida potestate nutritae non solum ipsae augentur amplissimis magnitudinibus, sed earum quoque venae umoris copia repletae urgentis¹ liquoris abundantia saturantur. Cum autem excisae et dolatae vitalem potestatem amiserunt, venarum rigore permanente siccescendopropterraritatem fiunt inanes et evanidae, ideoque in aedificiis non possunt habere diuturnitatem.
- ² Quae autem ad solis cursum spectantibus locis procreantur, non habentes interveniorum² raritates siccitatibus exsuctae solidantur, quia sol non modo ex terra lambendo sed etiam ex arboribus educit umores. Itaque, sunt in apricis regionibus, spissis venarum crebritatibus solidatae non habentes ex umore raritatem; quae, cum in materiem perdolantur, reddunt magnas utilitates ad vetustatem. Ideo infernates, quod ex apricis locis adportantur, meliores sunt, quam quae ab opacis de supernatibus advehuntur.
- ³ Quantum animo considerare potui, de copiis quae sunt necessariae in aedificiorum conparationibus,

¹ turgentes *rec* : urgentes *H*.

² interveniorum *Joc* : inter venarum *H*.

BOOK II. c. x.

round and in the middle of the curve almost touches the shores of the Adriatic. In its circuit it reaches the opposite straits.¹ The nearer slope, which turns to the regions of Etruria and Campania, has a sunny aspect. For it has an unbroken direction towards the sun's course. But the further slope, which inclines to the Adriatic, lies towards the northern quarter, and is bounded by unbroken tracts of land overshadowed and gloomy. And so the trees which grow in that part absorb a humid element. Not only do they grow to an immense size, but their pores, being filled with a supply of moisture, are saturated with an abundance of pressing fluid. But when they are cut down and axed they lose their vital force: remaining with the pores stiff and open, they dry, become hollow and perishable, and so cannot last in buildings. 2. But those which grow in places facing the sun's course, lacking the open spaces of the pores, are drained by dryness and solidified. For the sun licks up and draws moisture not only from the ground but also from trees. And so the trees in sunny regions are solidified by the closeness of their pores, and are free from the attenuation which is caused by moisture. When they are hewn into timber they furnish great advantages for durability. Therefore the lowland pine because it is brought from sunny districts is better than that which is brought from sunless districts in the highlands.

3. As far as I have been able to consider them in my mind I have set forth the supplies which are necessary in the erection of buildings, the natural

¹ The Apennines go from north to south almost to Brindisi.

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et quibus temperaturis e rerum natura principiorum habere videantur mixtionem quaeque insunt in singulis generibus virtutes et vitia, uti non sint ignota aedificantibus, exposui. Ita, qui potuerint eorum praeceptorum sequi praescriptiones, erunt prudentiores singulorumque generum usum eligere poterunt in operibus. Ergo quoniam de apparitionibus est explicatum, in ceteris voluminibus de ipsis aedificiis exponitur; et primum de deorum immortalium aedibus sacris et de earum symmetriis et proportionibus, uti ordo postulat, insequenti perscribam.

BOOK II. c. x.

combinations by which they seem to have their elements mixed, the excellences and defects which are present in their several kinds, so that they may not be unknown to persons engaged in building. Thus, if anyone can follow out the instructions laid down, he will be wiser and more able in his work to choose the use of the several kinds of material. Since then we have explained the modes of preparation, in the remaining books we set forth the kinds of building. And first, as order demands, I will describe in the following book the temples of the immortal gods, their symmetries and proportions.

BOOK III

LIBER TERTIUS

- 1 DELPHICUS Apollo Socratem omnium sapientissimum Pythiae responsis est professus. Is autem memoratur prudenter doctissimeque dixisse, oportuisse hominum pectora fenestrata et aperta esse, uti non occultos haberent sensus sed patentes ad considerandum. Utinam vero rerum natura sententiam eius secuta explicata et apparentia ea constituisset ! Si enim ita fuisset, non solum laudes aut vitia animorum ad manum aspicerentur, sed etiam disciplinarum scientiae sub oculorum consideratione subiectae non incertis iudiciis probarentur, sed et doctis et scientibus auctoritas egregia et stabilis adderetur. Igitur quoniam haec non ita, sed uti natura rerum voluit, sunt constituta, non efficitur ut possint homines obscuratis sub pectoribus ingeniis scientias artificiorum penitus latentes, quemadmodum sint, iudicare. Ipsique artifices pollicerentur suam prudentiam, si non pecunia sint copiosi sed vetustate officinarum habuerint notitiam ; aut etiam gratia forensi et eloquentia cum fuerint parati, pro industria studiorum auctoritates possunt habere, ut eis, quod
- 2 profitentur scire, id crederetur. Maxime autem id animadvertere possumus ab antiquis statuariis et pictoribus, quod ex his, qui dignitates notas et

¹ The Greeks used *technites*, the Romans *artifex*, for all handworkers whether artists or artisans.

BOOK III

PREFACE

1. DELPHIC Apollo, by the replies of the Pythian priestess, declared Socrates the wisest of all men. He is recorded to have said with wisdom and great learning that the hearts of men ought to have had open windows so that they might not keep their notions hidden, but open for inspection. Would that Nature had followed his opinion, and made them explicit and manifest! For if it had been so, not only would the merits or defects of human minds be seen at once, but the knowledge of disciplines also, lying under the view of the eyes, would be tested by no uncertain judgments; and a distinguished and lasting authority would be added both to learned and to accomplished men. Therefore since these things have been ordained otherwise, and as Nature willed, it is impossible for other men, when talent is concealed in the breast, to judge how such deeply hidden knowledge of the arts really stands. Yet those craftsmen¹ themselves would offer their skill who while they lack wealth yet have the knowledge based on workshop experience; or indeed when they are equipped with the graceful eloquence of the pleader, they can gain the authority corresponding to their industry, and have the credit of knowing what they profess.

2. Now we can best observe this in the case of ancient statuaries and painters; for of these, those who have a recognised dignity and the influence

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commendationis gratiam habuerunt, aeterna memoria ad posteritatem sunt permanentes, uti Myron, Polycletus, Phidias, Lysippus ceterique, qui nobilitatem ex arte sunt consecuti. Namque ut civitatibus magnis aut regibus aut civibus nobilibus opera fecerunt, ita id sunt adepti. At qui non minori¹ studio et ingenio sollertiaque fuerunt nobilibus et humili fortuna civibus non minus egregie perfecta fecerunt opera, nullam memoriam sunt adsecuti, quod hi non ab industria neque artis sollertia sed a Felicitate fuerunt decepti,² ut Hegias³ Atheniensis, Chion Corinthius, Myagrus Phocaeus, Pharax Ephesius, Boedas Byzantius etiamque alii plures. Non minus item, pictores, uti Aristomenes Thasius, Polycles et Androcydes⁴ <Cyzice>⁵ni, Theo Magnes⁶ ceterisque, quos neque industria neque artis studium neque sollertia defecit, sed aut rei familiaris exiguitas aut inbecillitas fortunae seu in ambitione certationis contrariorum³ superatis⁷ obstitit eorum dignitati. Nec tamen est admirandum, si propter ignotitiam artis virtutes obscurantur, sed maxime indignandum, cum etiam saepe blandiatur gratia conviviorum a veris iudiciis ad falsam probationem. Ergo, uti Socrati placuit, si

¹ minori *H.* ² decepti *e*₂: desepti *H.*

³ Hegias *Ro* (cf. *Plin.* 34. 49 et 78): hellas *H.*

⁴ Androcydes *Kr* (cf. *Plin.* 35, 64): andramithes *H.*

⁵ Cyziceni *Kr* (cf. *Plut. Pelop.* 25): ni *H.*

⁶ Magnes *Mar*: magnis *H.*

⁷ superatis *Joc*: superati *H.*

¹ Book I. i. 13.

² The sculptor of the Parthenon: the work was carried out under his general direction. He was the actual sculptor of the Images of Athena at Athens, and of Jupiter (Zeus) at Olympia.

BOOK III. PREFACE

based on commendation abide to after times in an everlasting remembrance : Myron,¹ Polyclitus,¹ Phidias,² Lysippus³ and others who from their art have attained renown. For they got it by working for great states or kings or famous citizens. But those who had not less eagerness, and were distinguished by talent and skill, but being of humble fortune executed for their fellow-citizens works not less perfect, gained no reputation. For they were left behind not in perseverance or in skill but by Good Fortune: for example, Hegias⁴ of Athens, Chion of Corinth, Myagrus the Phocæan,⁵ Pharax of Ephesus, Boedas of Byzantium⁶ and many others also; painters also not less, such as Aristomenes the Thasian, Polycles and Androcydes⁷ of Cyzicus, Theo⁸ the Magnesian, and others to whom neither industry nor craftsman's zeal nor skill was lacking: but their reputation was hindered, either by scanty possessions, or poor fortune, or the victory of rivals in competitions. 3. Yet we must not be surprised if excellence is in obscurity through the public ignorance of craftsmanship. But we ought to be specially indignant when also, as often happens, social influence beguiles men from exact judgments to a feigned approval. Therefore, as Socrates

¹ The sculptor of the Apoxyomenus, represented by the Vatican copy.

² Rival of Phidias. His "Horse-riders" was a famous piece.

³ Carved athletes, Plin. *N.H.* XXXIV. 91.

⁴ Pupil of Lysippus, Plin. *N.H.* XXXIV. 66, carved figure praying, *ib.* 73.

⁵ Contemporary and rival of Zeuxis, Plin. *N.H.* XXXV. 64.

⁶ Painted the madness of Orestes, Plin. *N.H.* XXXV. 144.

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ita sensus et sententiae scientiaeque disciplinis auctae perspicuae et perlucidae fuissent, non gratia neque ambitio valeret, sed si qui veris certisque laboribus doctrinarum pervenissent ad scientiam summam, eis ultro opera traderentur. Quoniam autem ea non sunt inlustria neque apparentia in aspectu, ut putamus oportuisse, et animadverto potius indoctos quam doctos gratia superare, non esse certandum iudicans cum indoctis ambitione, potius his praeceptis editis ostendam nostrae scientiae virtutem.

- 4 Itaque, imperator, in primo volumine tibi de arte et quas habeat ea virtutes quibusque disciplinis oporteat esse auctum architectum, exposui et subieci causas, quid ita earum oporteat eum esse peritum, rationesque summae architecturae partitione distribui finitionibusque terminavi. Deinde, quod erat primum et necessarium, de moenibus, quemadmodum eligantur loci¹ salubres, ratiocinationibus explicui, ventique qui sint et e quibus <regionibus>² singuli spirant, deformationibus grammicis³ ostendi, platearumque et vicorum uti emendate fiant distributiones in moenibus, docui et ita finitionem primo volumine constitui. Item in secundo de materia, quas habeat in operibus utilitates et quibus virtutibus e natura rerum est comparata, peregi. Nunc in tertio de deorum immortalium aedibus sacris dicam et, uti oporteat, per-scriptas exponam.

¹ loci *rec* : locis *H.*

² *add. Joc.*

³ grammicis *Joc* : grammaticis *H.*

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thought, if human notions and opinions and knowledge increased by study were manifest and transparent, neither influence nor intrigue would avail; but commissions would be entrusted to such persons as had attained the highest knowledge by their genuine and assured professional labour. Since, however, these things are not conspicuous nor apparent to the sight, as we think they ought to have been, and I perceive the ignorant excel in influence rather than the learned, I judge that we must not rival the ignorant in their intrigues; but I will rather display the excellence of our knowledge by the publication of these rules.

4. Therefore, your Highness, in the first book, I set before you our craft and its excellences and the studies by which the architect should improve himself; I furnished the reasons why he ought to be skilled in them; I analysed the methods of architecture generally, and assigned their limits by my definitions. Then, as matter of prime necessity, I explained by argument with reference to walled cities, how healthy sites are chosen and showed by geometrical figures the various winds, and the quarters from which they severally blow. I taught the way to distribute in an accurate manner the main and side streets within the walls, and so completed my first book. In the second book I dealt with the employment of materials in building and with the excellences which they naturally possess. Now in the third book I will speak of the temples of the Gods and will set them out in detail in a proper manner.

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I

- 1 AEDIUM compositio constat ex symmetria, cuius rationem diligentissime architecti tenere¹ debent. Ea autem paritur a² proportione, quae graece *analogia* dicitur. Proportio est ratae partis membrorum in omni opere totiusque³ commodulatio, ex qua ratio efficitur symmetriarum. Namque non potest aedis ulla sine symmetria atque proportionem habere compositionis, nisi uti ad hominis bene figurati membrorum habuerit exactam rationem.
- 2 Corpus enim hominis ita natura composuit, uti os capitis a mento ad frontem summam et radices imas capilli esset decimae partis, item manus palma ab articulo ad extremum medium digitum tantundem, caput a mento ad summum verticem octavae,⁴ cum cervicibus imis ab summo pectore ad imas radices capillorum sextae, <a medio pectore>⁵ ad summum verticem quartae. Ipsius autem oris altitudinis tertia est pars ab imo mento ad imas nares, nasum ab imis naribus ad finem medium superciliorum tantundem, ab ea fine ad imas radices capilli⁶ frons efficitur item tertiae partis. Pes vero altitudinis corporis sextae,⁷ cubitum quartae, pectus item quartae. Reliqua quoque membra suas⁸ habent commensus proportionem, quibus etiam antiqui

¹ teneri *H.*

² paritur a *rec* : paritura *pr. H.*

³ totiusque *Joc* : totaque *H.*

⁴ octae *H.*

⁵ *add. Gal.*

⁶ capillis *H.*

⁷ extae *H.*

⁸ suas *Lor* : suos *H.*

¹ The Greek and Roman artists treated the human body as the standard of beauty. The statement in the fourth Gospel ii. 21 refers to the body as the abode of the Spirit.

BOOK III. c. I.

CHAPTER I

THE PLANNING OF TEMPLES

1. THE planning of temples depends upon symmetry: and the method of this architects must diligently apprehend. It arises from proportion (which in Greek is called *analogia*). Proportion consists in taking a fixed module, in each case, both for the parts of a building and for the whole, by which the method of symmetry is put into practice. For without symmetry and proportion no temple can have a regular plan; that is, it must have an exact proportion worked out after the fashion of the members of a finely-shaped human body.¹ 2. For Nature² has so planned the human body that the face from the chin to the top of the forehead and the roots of the hair is a tenth part; also the palm of the hand from the wrist to the top of the middle finger is as much; the head from the chin to the crown, an eighth part; from the top of the breast with the bottom of the neck to the roots of the hair, a sixth part; from the middle of the breast to the crown, a fourth part; a third part of the height of the face is from the bottom of the chin to the bottom of the nostrils; the nose from the bottom of the nostrils to the line between the brows, as much; from that line to the roots of the hair, the forehead is given as the third part. The foot is a sixth of the height of the body; the cubit a quarter, the breast also a quarter. The other limbs also have their own proportionate measurements. And by using

¹ Here the intention of Nature is thought to appear in a type or canon such as that of Polyclitus, or, later, of Lysippus.

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- pictores et statuarii nobiles usi magnas et infinitas
3 laudes sunt adsecuti. Similiter vero sacrarum aedium membra ad universam totius magnitudinis summam ex partibus singulis convenientissimum debent habere commensus responsum. Item corporis centrum medium naturaliter est umbilicus. Namque si homo conlocatus fuerit supinus¹ manibus et pedibus pansis circinique conlocatum centrum in umbilico eius, circumagendo rotundationem utrarumque manuum et pedum digiti linea tangentur. Non minus quemadmodum schema² rotundationis in corpore efficitur, item quadrata designatio in eo invenietur. Nam si a pedibus imis ad summum caput mensum erit eaque mensura relata fuerit ad manus pansas,³ invenietur eadem latitudo uti altitudo, quemadmodum areae quae ad normam sunt quadratae.
- 4 Ergo si ita natura composuit corpus hominis, uti proportionibus membra ad summam figurationem eius respondeant, cum causa constituisse videntur antiqui, ut etiam in operum perfectionibus singulorum membrorum ad universam figurae speciem habeant commensus exactionem. Igitur cum in omnibus operibus ordines traderent, maxime in aedibus deorum, operum et laudes et culpae aeternae solent permanere.
- 5 Nec minus mensurarum rationes, quae in omnibus operibus videntur necessariae⁴ esse, ex corporis membris collegerunt, uti digitum, palmum, pedem, cubitum, et eas distribuerunt in perfectum numerum, quem Graeci *teleon* dicunt. Perfectum autem antiqui

¹ sopinus *H.*

² scaema *H.*

³ spansas *H.*

⁴ necessaria *H.*

¹ The explanation of the orders by reference to the proportions of the human body follows: Book IV. i.

BOOK III. c. I.

these, ancient painters and famous sculptors have attained great and unbounded distinction. 3. In like fashion the members of temples ought to have dimensions of their several parts answering suitably to the general sum of their whole magnitude. Now the navel is naturally the exact centre of the body. For if a man lies on his back with hands and feet outspread, and the centre of a circle is placed on his navel, his figure and toes will be touched by the circumference. Also a square will be found described within the figure, in the same way as a round figure is produced. For if we measure from the sole of the foot to the top of the head, and apply the measure to the outstretched hands, the breadth will be found equal to the height, just like sites which are squared by rule. 4. Therefore if Nature has planned the human body so that the members correspond in their proportions to its complete configuration, the ancients seem to have had reason in determining that in the execution of their works they should observe an exact adjustment of the several members to the general pattern of the plan. Therefore, since in all their works they handed down orders,¹ they did so especially in building temples, the excellences and the faults of which usually endure for ages.

5. Moreover, they collected from the members of the human body the proportionate dimensions which appear necessary in all building operations; the finger or inch, the palm, the foot, the cubit. And these they grouped into the perfect number² which the Greeks call *teleon*.³ Now the ancients

¹ ² Plato's *Republic*, 546.

³ *Teleon* is a better spelling than *teleion* and is found in *H*.

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instituerunt numerum qui decem dicitur; namque ex manibus digitorum numerum; ab palmo pes est inventus. Si autem in utrisque palmis ex articulis ab natura decem sunt perfecti, etiam Platoni placuit esse eum numerum ea re perfectum, quod ex singularibus rebus, quae *monades* apud Graecos dicuntur, perficitur decusis.¹ Qui simul autem undecim aut duodecim sunt facti, quod superaverint, non possunt esse perfecti, donec ad alterum decusis perveniant; singulares enim res particulae sunt eius numeri.

6 Mathematici vero contra disputantes ea re perfectum dixerunt esse numerum qui sex dicitur, quod is numerus habet partitiones eorum rationibus sex numero convenientes sic : sextantem unum, trientes duo,² semissem tria, besem quem *dimoeron* dicunt quattuor, quintarium quem *pentemoeron* dicunt quinque, perfectum sex. Cum ad supplicationem³ crescat, supra sex adiecto asse *ephectum*; cum facta sunt octo, quod est tertia adiecta, tertiarium alterum,⁴ qui *epitritos* dicitur; dimidia adiecta cum facta sunt novem, sesquialterum, qui *hemioli* appellatur; duabus partibus additis et decusis facto bes alterum, quem *epidimoerum* vocitant; in undecim numero quod adiecti sunt quinque, quintarium, quem *epipempton* dicunt; duodecim autem, quod ex duobus numeris

7 simplicibus est effectus, *diplasiona*. Non minus etiam, quod pes hominis altitudinis sextam habet

¹ decusisq. *H*. ² (trientem) duo *Joc* : trientes duos *H*.

³ supplicationem *H* = *ὑποπλέκειν* (subnectere).

⁴ alterum *Mar* : autem *H*.

¹ The mathematical notion of "elegance" is here seen in an early form. The Pythagoreans distinguished between the "esoteric" mathematics of elegance, and the "exoteric"

BOOK III. c. 1.

determined as perfect the number which is called ten.¹ For from the hands they took the number of the inches; from the palm, the foot was discovered. Now while in the two palms with their fingers, ten inches are naturally complete, Plato considered that number perfect, for the reason that from the individual things which are called *monades* among the Greeks, the decad² is perfected. But as soon as they are made eleven or twelve, because they are in excess, they cannot be perfect until they reach the second decad. For individual things are minor parts of that number. 6. But mathematicians, disputing on the other side, have said that the number called six³ is perfect for the reason that this number has divisions which agree by their proportions with the number six. Thus a sixth is one; a third is two; a half is three; two-thirds, which they call *dimoeros*, four; five-sixths, which they call *pentemoeros*, five; the perfect number, six. When it grows to the double, a twelfth added above six makes *ephectos*; when eight is reached, because a third is added, there is a second third, which is called *epitritos*; when half is added and there are nine, there is half as much again, and it is called *hemiolios*; when two parts are added and a decad is made, we have the second two-thirds, which they call *epidimoeros*: in the number eleven, because five are added, we have five-sixths, which they call *epipemptos*; twelve, because it is produced from two simple numbers, they call *diplasios*. 7. Not less also because the foot has the sixth part of a or applied mathematics of daily practice. They regarded 10 as the perfect number.

¹ 10 = 1 + 2 + 3 + 4. Plato follows the Pythagoreans.

² On perfection of number 6, Aug. *Civ. Dei*, XI. 30.

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partem, (ita etiam, ex eo quod perficitur pedum numero, corporis sexies ¹ altitudinis terminavit) eum perfectum constituerunt, cubitumque animadverterunt ex sex palmis constare digitisque xxiii. Ex eo etiam videntur civitates Graecorum fecisse, quemadmodum cubitus est sex palmorum, in drachma qua nummo ² uterentur, aereos signatos uti asses ex aequo ³ sex, quos obolos appellant, quadrantesque obolorum, quae alii dichalca, nonnulli trichalca dicunt, pro digitis viginti quattuor in drachma constituuisse.

8 Nostri autem primo fecerunt antiquum numerum et in denario denos aeris constituerunt, et ea re compositio nominis ad hodiernum diem denarium retinet. Etiamque quarta pars quod efficiebatur ex duobus assibus et tertio semisse, sestertium vocitaverunt. Postea quam animadverterunt utrosque numeros esse perfectos, et sex et decem, utrosque in unum coiecerunt et fecerunt perfectissimum decusis sexis. Huius autem rei auctorem invenerunt pedem. E cubito enim cum dempti sunt palmi duo, relinquitur pes quattuor palmorum, palmus autem habet quattuor digitos. Ita efficitur, ut habeat pes sedecim digitos et totidem asses aeracius denarius.

9 Ergo si convenit ex articulis hominis numerum inventum esse et ex membris separatis ad universam corporis speciem ratae partis ⁴ commensus fieri responsum, relinquitur, ut suscipiamus eos, qui etiam

¹ seies *H.* ² num(m)o *Schn* : numero *H.*

³ ex aequo *Joc* : ex quo *H.* ⁴ partes *H.*

¹ The *as* was a Roman bronze coin successively reduced from 1 lb. (12 oz.) to 4 oz., 2 oz., 1 oz. and $\frac{1}{2}$ oz. The reductions took place at financial crises probably in 268 B.C. after war with Pyrrhus, 242 B.C. end of 1st Punic war, 217 beginning of 2nd Punic war, 89 in Social war. The *Lex Valeria* of 86 B.C.

BOOK III. c. i.

man's height, and also because six times, that is the number six, in that it is completed by the number of feet, determined the height of the body, they fixed that number as perfect, observing that the cubit consists of six palms and twenty-four fingers. Hence also the cities of the Greeks seem to have made in a like fashion (just as the cubit is of six palms) six parts of the *drachma*, the coin which they use, stamped bronze coins like *asses*,¹ which they call *obols*; and to have fixed twenty-four quarter obols, called by some *dichalca*, by others *trichalca* to correspond to the fingers. 8. We, however, at first followed the ancient number, and in the *denarius* fixed ten bronze coins; whence to this day the derived name keeps the number ten (*denarius*). And also because the fourth part was made up of two asses and a half, they called it *sestertius*.² But afterwards they perceived that both numbers were perfect, both the six and the ten; and they threw both together, and made the most perfect number sixteen. Now of this they found the origin in the foot. For when two palms are taken from the cubit, there is left a foot of four palms, and the palm has four fingers. So it comes that the foot has sixteen fingers, and the bronze denarius as many asses.

9. Therefore, if it is agreed that number is found from the articulation of the body, and that there is a correspondence of the fixed ratio of the separate members to the general form of the body, it remains that we take up those writers who in planning the

allowed debtors to take advantage of the last reduction so that they only had to pay one-fourth of their debts.

² i.e. *semis tertius*.

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aedes deorum immortalium constituentes ita membra operum ordinaverunt, ut proportionibus et symmetriis separatae atque universae convenientesque efficerentur eorum distributiones.

II

- 1 AEDIUM autem principia sunt, e quibus constat figurarum aspectus; et primum in antis, quod graece *naos en parastasin* dicitur, deinde prostylos, amphiprostylos, peripteros, pseudodipteros, hypaethros.¹ Horum exprimuntur formationes his rationibus.²
- 2 In antis erit aedes, cum habeat in fronte antas parietum qui cellam circumcludunt, et inter antas in medio columnas duas supraque fastigium symmetria ea conlocatum, quae in hoc libro fuerit perscripta. Huius autem exemplar erit ad tres Fortunas ex tribus
- 3 quod est proxime portam Collinam. Prostylos omnia habet quemadmodum in antis, columnas autem contra antas angulares duas supraque epistylia, quemadmodum et in antis, et dextra ac sinistra in versuris singula. Huius exemplar est in insula
- 4 Tiberina in aede Iovis et Fauni. Amphiprostylos omnia habet ea, quae prostylos, praetereaque habet in postico ad eundem modum columnas et fastigium.

¹ hypetros *H*

² *post* rationibus in *H* quemadmodum et . . . exemplar, *del. Joc.*

1 "Temple in pilasters." 2 "With columns in front."

3 "With columns on both fronts."

4 "With columns all round."

BOOK III. c. I.—c. II.

temples of the immortal gods so ordained the parts of the work that, by the help of proportion and symmetry, their several and general distribution is rendered congruous.

CHAPTER II

ON THE KINDS OF TEMPLES

1. It is from the plan of a temple that the effect of its design arises. And first *in antis*, which in Greek is called *naos en parastasin*¹; next, *prostyle*,² *amphiprostyle*,³ *peripteral*,⁴ *pseudodipteral*,⁵ *hypæthral*.⁶ The designs of these are formulated in the following manner. 2. A temple will be *in antis* when it has in front, pilasters terminating the walls which enclose the shrine, and in the middle, between the pilasters, two columns, and above, a gable; built with the symmetry to be set forth in this book. An example of this will be the Temple of Fortune, nearest of the three to the Colline Gate.⁷ 3. The *prostyle* has everything like the temple *in antis*, except two angle columns over against the pilasters; and above, entablatures as *in antis* which return at the angles on either side. An example of this is on the island in the Tiber, namely, the Temple of Jupiter and Faunus.⁸ 4. The *amphiprostyle* has everything like the *prostyle*, and besides has columns and a pediment at the back.

⁵ "With columns all round set at a distance from the temple walls."

⁶ "With interior open to the sky."

⁷ Lanciani, *R.E.* 421; Platner, 216.

⁸ Ovid, *Fasti*, I. 293. Liv. XXXIII. 42; XXXIV. 53; XXXV. 41. Platner, 205.

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- 5 Peripteros autem erit, quae habebit in fronte et postico senas columnas, in lateribus cum angularibus undenas. Ita autem sint hae columnae conlocatae, ut intercolumnii latitudinis intervallum sit a parietibus circum ad extremos ordines columnarum, habeatque ambulationem circa cellam aedis, quemadmodum est in porticu Metelli Iovis Statoris Hermodori¹ et ad Mariana Honoris et Virtutis sine
- 6 postico a Mucio facta. Pseudodipteros autem sic conlocatur, ut in fronte et postico sint columnae octonae, in lateribus cum angularibus quinae denae. Sint autem parietes cellae contra quaternas columnas medianas in fronte et postico. Ita duorum intercolumniorum et unae crassitudinis columnae spatium erit ab parietibus² circa ad extremos ordines columnarum. Huius exemplar Romae non est, sed Magnesiae Dianae Hermogenis Alabandei et Apollinis
- 7 a Menesthe facta. Dipteros autem octastylus et pronao et postico, sed circa aedem duplices habet ordines columnarum, uti est aedis Quirini dorica et Ephesi Dianae ionica a Chersiphrone constituta.
- 8 Hypaethros vero decastylus est in pronao et postico. Reliqua omnia eadem habet quae dipteros, sed interiore parte columnas in altitudine duplices, remotas a parietibus ad circumitionem ut porticus peristy-

¹ Hermodori *Turnebus*: hermodi *H.*

² ab par. *G*: appar. *H.*

¹ Liv. I. 12; Lanciani, *R.E.* 200; Platner, 304.

² Cic. *de Oratore*, I. 62. ³ Cic. *Verr.* IV. 121.

⁴ VII. *pref.* 17.

⁵ Burn, *Rome*, 193; Platner, 258.

⁶ Plate B.

BOOK III. c. II.

5. The *peripteral* will be that which shall have six columns in front and six at the back, and on either side eleven, counting in the angle columns. Now these columns are to be so placed that there is all round a distance the width of an intercolumniation, between the walls and the outer rows of the columns, This provides a walk round the cell of the temple, such as there is at the temple of Jupiter Stator¹ by Hermodorus² in the Portico of Metellus, and the temple of Honor and Virtus³ built without a posticum, by Mucius⁴ near the Monument of Marius.⁵ 6. The *pseudodipteros*⁶ is so planned that there are eight columns both in front and at the back, and fifteen on each side, including the angle columns. But the walls of the cella are to face the four middle columns in front and at the back. Thus there will be a space all round, from the walls to the outside rows of the columns, of two intercolumniations and the thickness of one column. There is no example of this at Rome; but there is at Magnesia the temple of Diana built by Hermogenes of Alabanda, and the temple of Apollo by Menesthes. 7. The *dipteros*⁷ has eight columns in front and at the back, but it has double rows of columns round the sanctuary, like the Doric temple of Quirinus,⁷ and the Ionic temple of Diana at Ephesus built by Chersiphron. 8. The *hypaethral* temple has ten columns in front and at the back. For the rest it has everything like the dipteral, except that in the interior it will have two stories of columns, at a distance from the walls all round like the colonnade of a peristyle. The centre has

¹ At Rome, Cic. *ad Att.* XII. 45; XIII. 28. Burn, *Rome*, 249; Platner 439. Plate B.

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liorum. Medium autem sub divo est sine tecto. Aditus valvarum et utraque parte in pronao et postico. Huius item exemplar Romae non est, sed Athenis octastylus et templo Olympio.

III

- 1 SPECIES autem aedium sunt quinque, quarum ea sunt vocabula : pycnostylus, id est crebris columnis; systylus paulo remissioribus; diastylus¹ amplius patentibus; rare² quam oportet inter se diductis araeostylus³; eustylus⁴ intervallorum iusta distributione. Ergo pycnostylus est, cuius intercolumnio unius et dimidiatae columnae crassitudo interponi potest, quemadmodum est divi Iulii et in Caesaris foro Veneris et si quae aliae sic sunt compositae. Item systylus⁵ est, in quo duarum columnarum crassitudo in intercolumnio poterit conlocari, et spirarum plinthis aequae magnae sint et spatio, quod fuerit inter duas plinthis, quemadmodum est Fortunae Equestris ad theatrum lapideum reliquaeque,⁶ quae eisdem rationibus sunt compositae.
- 3 Haec utraque genera vitiosum habent usum. Matres enim familiarum cum ad supplicationem gradibus ascendunt, non possunt per intercolumnia amplexae adire, nisi ordines fecerint; item valvarum adpectus⁷ abstruditur columnarum crebritate ipsaque signa

¹ diastylus *ed. Ven* : interestylus *H.*

² rare for rarius *H.*

³ spatiis intercolumniorum *add. G* : om. *H.*

⁴ eustylus *ed. Fl* : et stilos *H.*

⁵ sistilos *G*, stylos *H.*

⁶ reliquae quaeque *H.*

⁷ abspectus *H.*

¹ Lanciani, *R.E.* 269.

² *Op. cit.* 302; Platner, 226.

BOOK III. C. II.—C. III.

no roof and is open to the sky. There are folding doors in front and at the back. Of this there is no example at Rome; but there is the Octastyle at Athens, in the Olympian temple.

CHAPTER III

ON THE ELEVATIONS OF TEMPLES

1. THERE are five elevations of temples; of which the names are as follows: pycnostyle, that is with close columns; systyle, with the spaces of the intercolumniations a little more open; diastyle, wider still; with intercolumniations more open than they should be, araeostyle; eustyle, with the just distribution of intervals. 2. So then pycnostyle is that in the intercolumniations of which the thickness of a column and a half can be interposed, as in the temple of Julius,¹ and of Venus² in the Forum of Caesar, and any others which are so arranged. The systyle also is that in which the thickness of two columns can be placed in the intercolumniations, and the plinths of the bases are equally great with the space between two plinths, as is the temple of Fortuna Equestris³ against the Stone Theatre,⁴ and the others which are arranged in the same proportions. 3. These two kinds are objectionable in use. For when matrons come up by the steps to give thanks, they cannot approach between the columns arm in arm but in single file; further, the view of the doors is taken away by the numerous columns, and the statues themselves are

¹ Liv. XL. 40; XLII. 3; Tac., *Ann.* III. 71; Platner, 215.

⁴ Lanciani, *R.E.* 461; Platner, 515.

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obscurantur; item circa aedem propter angustias
 4 inpediuntur ambulationes. Diastyli autem haec erit
 compositio, cum trium columnarum crassitudinem
 intercolumnio interponere possumus, tamquam est
 Apollinis et Dianae aedis. Haec dispositio hanc
 5 habet difficultatem, quod epistylia propter inter-
 vallorum magnitudinem franguntur. In araeostylis
 autem nec lapideis nec marmoreis epistyliis uti datur,
 sed inponendae de materia trabes perpetuae. Et
 ipsarum aedium species sunt varicae,¹ barycephalae,²
 humiles, latae, ornanturque signis fictilibus aut aereis
 inauratis earum fastigia tuscanico more, uti est ad
 Circum Maximum Cereris³ et Herculis Pompeiani,
 item Capitoli.⁴

6 Reddenda nunc est eustyli⁵ ratio, quae maxime
 probabilis et ad usum et ad speciem et ad firmitatem
 rationes habet explicatas. Namque facienda sunt
 in intervallis spatia duarum columnarum et quartae
 partis columnae crassitudinis, mediumque inter-
 columnium unum, quod erit in fronte, alterum, quod
 in postico, trium columnarum crassitudine. Sic
 enim habebit et figurationis aspectum venustum
 et aditus usum sine inpeditionibus et circa cellam
 7 ambulatio auctoritatem. Huius autem rei ratio explica-
 bitur sic. Frons loci quae in aede constituta fuerit, si
 tetrastylus⁶ facienda fuerit, dividatur in partes xi s⁷
 praeter crepidines et proiecturas spirarum; si sex

¹ varicae *Turnebus*: baryce *H.*

² caeteris *H.*

⁵ estyli *H.*

⁷ xi s *Joc*: decusas semis *H.*

² parycephale *H.*

⁴ capituli *H.*

⁶ &trastylus *H.*

¹ On the Palatine. The only instance of the double name, Platner, 17 n.

BOOK III. c. III.

obscured; walking round the temple is hindered on account of the narrow intervals. 4. Of the diastyle, the arrangement is as follows: when we can interpose the thickness of three columns in the intercolumniation, as in the case of the Temple of Apollo and Diana.¹ Such a disposition presents this difficulty, that the architraves break because of the wide openings. 5. In araeostyle buildings it is not given to use stone or marble architraves, but continuous wooden beams are to be employed. And the designs of the buildings themselves are straddling, top-heavy, low, broad. The pediments are ornamented with statues of terra-cotta or gilt bronze in the Etruscan fashion, as is the Temple of Ceres² at the Circus Maximus, Pompey's Temple of Hercules,³ and the Capitoline Temple.⁴

6. We must now render an account of the eustyle, which is specially to be approved, and has proportions set out for convenience, beauty and strength. For in the intervals the width of two and a quarter columns is to be made, and the middle intercolumniation, one in the front and one in the back, is to be three columns wide. For so the building will have both a graceful appearance in its configuration, and a convenient approach; and the walk round the sanctuary will have dignity. 7. The method of this arrangement is to be explained as follows. The front of the site which has been set out in the building is to be divided, if it is to be tetrastyle, into $11\frac{1}{2}$ parts, excluding the plinths and the projections of the

² Plin. *N.H.* XXXV. 154; Tac. *Ann.* II. 49; Burn, *Rome*, 292.

³ Plin. *N.H.* XXXIV. 57; Burn, *Rome*, 40; Lanciani, *R.E.* 458; Platner, 255.

⁴ Burn, *Rome*, xxvi.; Platner, 297.

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erit columnarum, in partes xviii¹; si octostylos constituetur, dividatur in xxiv² et semissem. Item ex his partibus sive tetrastyli sive hexastyli sive octostyli una pars sumatur, eaque erit modulus. Cuius moduli unius erit crassitudinis columnarum. Intercolumnia singula, praeter media,³ modulorum duorum et moduli quartae partis; mediana in fronte et postico singula ternum modulorum. Ipsarum columnarum altitudo modulorum habebunt iustam⁸ rationem. Huius exemplar Romae nullum habemus, sed in Asia Teo hexastylon⁴ Liberi Patris.

Eas autem symmetrias constituit Hermogenes, qui etiam primus *exo stylos*⁵ pseudodipterive rationem.⁶ Ex dipteri enim aedis symmetriae⁷ distulit interiores ordines columnarum xxxiv⁸ eaque ratione sumptus operasque compendii fecit. Is in medio ambulationi laxamentum egregie circa cellam fecit de aspectuque nihil inminuit, sed sine desiderio super-
vacuorum conservavit auctoritatem totius operis⁹ distributione. Pteromatos enim ratio et columnarum circum aedem dispositio ideo est inventa, ut aspectus propter asperitatem intercolumniorum habeat⁹ auctoritatem, praeterea, si ex imbrum¹⁰ aquae vis occupaverit et intercluserit hominum multitudinem, ut habeat in aede circaque cellam cum laxamento liberam moram. Haec autem ut explicantur in

¹ xviii *Joc*: decem novem *H*.

² xxiv *Joc*: viginti quinque *H*.

³ media *Lor*: mediam *H*.

⁴ theo *H*: exastilon *H*. ⁵ exostylum *H*: exo stylos *Gr*.

⁶ pseudo dipteri urationem *H*.

⁷ symmetriae *H*, ex *c. gen. Graecism*; cf. ex *c. acc.* reproductionem *Gal.* III. 18, *Am*.

⁸ xxxiv *Phil*: xxxviii *H*. ⁹ habeat *G*: hab& *H*.

¹⁰ ex imbrum *H*.

BOOK III. C. III.

bases; if the building is hexastyle, into 18 parts; if it shall be octastyle, into $24\frac{1}{2}$ parts. Further, of these parts, whether for tetrastyle, hexastyle, or octastyle, let one be taken, and that will be the module or unit. And of this module, one will be the thickness of the column. The several intercolumniations except those in the middle will be of two modules and a quarter; the middle intercolumniations at the front and at the back will be severally of three modules. The height of the columns will have a just proportion of modules.¹ 8. Of this we have no instance at Rome; but in Asia there is the hexastyle temple of Father Bacchus in Teos.

These proportions Hermogenes² determined, and he also was the first to use the exostyle or pseudodipteral arrangement. For from the plan of the dipteral temple he removed the interior rows of the thirty-four columns, and in that manner abridged the expense and the work. He made an opening for the ambulatory round the cella in a striking fashion, and in no respect detracted from the appearance. Thus without letting us miss the superfluous parts, he preserved the impressiveness of the whole work by his arrangement.³ 9. For the columns round the temple were so devised that the view of them was impressive, because of the high relief given to the intercolumniations; moreover, if a number of people have been unexpectedly cut off by showers of rain, they have plenty of room to linger in the building space. Thus far as is ex-

¹ *H* omits a passage interpolated here.

² Hermogenes was one of V.'s authorities.

³ A good instance of architectural criticism.

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pseudodipteris aedium dispositionibus. Quare videtur acuta magnaue sollertia effectus operum Hermogenis fecisse reliquisseque fontes, unde posteri possent haurire disciplinarum rationes.

- 10 Aedibus araeostylis columnae sic sunt faciendae, uti crassitudines earum sint partis octavae ad altitudines. Item in diastylo dimetienda est altitudo columnae in partes octo et dimidium, et unius partis columnae crassitudo conlocetur. In systylo altitudo dividatur in novem et dimidiam partem, et ex eis una ad crassitudinem columnae detur. Item in pycnostylo dividenda est altitudo in decem, et eius una pars facienda est columnae crassitudo. Eustyli¹ autem aedis columnae, uti systyli, in novem partibus² altitudo dividatur et dimidiam partem, et eius una pars constituatur in crassitudine imi scapi. Ita habebitur pro rata parte intercolumniorum ratio.
- 11 Quemadmodum enim crescunt spatia inter columnas, proportionibus adaugendae sunt crassitudinis³ scaporum. Namque si in araeostylo⁴ nona aut decima pars crassitudinis fuerit, tenuis et exilis apparebit, ideo quod per latitudinem intercolumniorum aer consumit et inminuit aspectu scaporum crassitudinem. Contra vero pycnostylis si octava pars crassitudinis fuerit, propter crebritatem et angustias intercolumniorum tumidam et invenustam efficiet speciem. Itaque generis operis oportet persequi symmetrias.

¹ eustyli *H.* ² partes *Joc* : partibus *H.*

³ crassitudines *G* : *nom. in is Am. H.*

⁴ simareostylo *H.*

¹ The Renaissance architects in Rome, *e.g.* Vignola and Palladio, combined the measurements of ancient buildings with the study of Vitruvius.

BOOK III. c. III.

plained in the pseudodipteral plans of temples. Hence there must have been great and subtle skill to produce the works of Hermogenes, and it has left sources from which posterity could draw their methods of study.¹

10. For araeostyle temples, the columns are to be so made that their diameters are one-eighth the height. Also in the diastyle, the height of the column is to be measured out into eight and a half parts, and let the diameter of the column be of one part. In the systyle let the height be divided into nine and a half parts, let one of those be given for the diameter of the column. Also in the pycnostyle, the height is to be divided into ten, and of that one part is to be made the diameter of the column. Now of the eustyle temple, as of the systyle, let the height be divided into nine and a half parts, and of that let one part be set up for the diameter of the bottom of the shaft. In this way the relation of the intercolumniations will be observed proportionately. 11. For in the measure by which the spaces between the columns grow, the diameters of the shafts are to be increased. For if in the araeostyle there shall be the ninth or tenth part of a diameter, it will appear thin and scanty; because through the width of the intercolumniations the air consumes and lessens in appearance the diameter of the shafts.² On the other hand, in pycnostyle temples if there shall be the eighth part of a diameter, because of the frequency and narrowness of the intercolumniations, it will produce a swollen and displeasing appearance. Therefore we must follow the symmetries required by the style of the work. The

² Reference to optics.

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Etiamque angulares columnae crassiores faciendae sunt ex suo diametro quinquagesima parte, quod eae ab aere circumciduntur et graciliores videntur esse aspicientibus. Ergo quod oculus fallit, ratio-
 12 cinatione est exequendum.¹ Contracturae autem in summis columnarum hypotrachelis² ita faciendae videntur, uti, si columna sit ab minimo ad pedes quinos denos, ima crassitudo dividatur in partes sex et earum partium quinque summa constituatur. Item³ quae erit ab quindecim pedibus ad pedes viginti, scapus⁴ imus in partes⁵ sex et semissem dividatur, earumque partium quinque et semisse superior crassitudo columnae fiat. Item quae erunt a pedibus viginti ad pedes triginta, scapus imus⁶ dividatur in partes septem, earumque sex summa contractura perficiatur. Quae autem ab triginta pedibus ad quadraginta alta erit, ima dividatur in partes septem et dimidiam; ex his sex et dimidiam in summo habeat contracturae rationem. Quae erunt ab quadraginta pedibus ad quinquaginta, item dividendae sunt in octo partes, et earum septem in summo scapo sub capitulo contrahantur. Item si
 13 quae altiores erunt, eadem ratione pro rata consti-
 tuantur⁷ contracturae. Haec autem propter altitudinis intervallum scandentis oculi species⁸ adiciuntur crassitudinibus temperaturae. Venustates enim persequitur visus, cuius si non blandimur voluptati proportionem et modulorum adiectionibus, uti quod fallitur temperatione adaugeatur, vastus et

¹ exaequendum *H.*

² hypotrachelis *H.*

³ itemq; *H.*

⁴ viginti capus *H.*

⁵ post partes *add. H.*, septem superior crassitudo columnae *del. Joc.*

⁶ imus *G*: is *H.*

⁷ constituentur *ed*: -atur *H.*

⁸ oculi *rec*: oculis *H*: species *H*: *genit. Kr.*

BOOK III. c. III.

angle columns also must be made thicker by the fiftieth part of their diameter, because they are cut into by the air and appear more slender to the spectators. Therefore what the eye cheats us of, must be made up by calculation. 12. The contractions, however, in the topmost necking of the columns, it seems, should be so made that from the smallest dimension up to fifteen feet, the lowest diameter should be divided into six parts and the top should be of five of those parts. Also in those which shall be from fifteen feet to twenty feet, the lowest part of the shaft is to be divided into six and a half parts; and of those parts five and a half are to be the upper diameter of the column. Also in those which shall be from twenty feet to thirty feet, let the lowest part of the shaft be divided into seven parts, and let the top contraction be made six of them. In the column which shall be from thirty to forty feet, let the lowest diameter be divided into seven and a half parts; of these let the column have six and a half at the top as the amount of contraction. Those which shall be from forty to fifty feet are also to be divided into eight parts, and these are to be contracted to seven at the top of the shaft under the capital. Further, if any are higher, let the contractions be determined proportionately in the same way. 13. It is on account of the variation in height that these adjustments are added to the diameters to meet the glance of the eye as it rises. For the sight follows gracious contours; and unless we flatter its pleasure, by proportionate alterations of the modules (so that by adjustment there is added the amount to which it suffers illusion), an uncouth and ungracious aspect will be

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invenustus conspicientibus remittetur aspectus. De adiectione, quae adicitur in mediis columnis, quae apud Graecos *entasis* appellatur, in extremo libro erit formata ratio eius, quemadmodum mollis et conveniens efficiatur, subscripta.

IV

- 1 FOUNDATIONES eorum operum fodiantur, si queat inveniri, ab solido et in solidum, quantum ex amplitudine operis pro ratione videbitur, extruaturque structura totum solum quam solidissima. Supraque terram parietes extruantur sub columnas dimidio crassiores quam columnae sunt futurae, uti firmiora sint inferiora superioribus; quae stereobates¹ appellantur, nam excipiunt onera. Spirarumque proiecturae non procedant extra solium; item supra parietis² ad eundem modum crassitudo servanda est. Intervalla autem concamaranda aut solidanda festucationibus, uti distineantur.³ Sin autem solidum non invenietur, sed locus erit congesticius⁴ ad imum aut paluster,⁵ tunc is locus fodiatur exinaniaturque et palis alneis⁶ aut oleagineis <aut> robusteis ustilatis configatur,⁷ sublicaque⁸ machinis adigatur quam creberrime, carbonibusque expleantur intervalla

¹ est ereobates *H.* ² parietis *Joc*: -tes *H.*

³ distineantur *Joc*: destineantur *H.*

⁴ congesticius *G*: coniesticius *H.*

⁵ paluster *G*: plai | ter *H.* ⁶ alneis *Joc*: saligneis *H.*

⁷ configatur *G*: configuratur *H.* ⁸ subligaque *H.*

¹ Hence the ornaments of a building should follow the lines of the structure in such a way as to support the proportions.

² Without a slight swelling of the shaft of a column, the straight upright line would strike the eye as hollowed inwards.

BOOK III. c. III.—c. IV.

presented to the spectators.¹ As to the swelling² which is made in the middle of the columns (this among the Greeks is called *entasis*), an illustrated formula will be furnished at the end of the book to show how the entasis may be done in a graceful and appropriate manner.

CHAPTER IV

ON THE FOUNDATIONS OF TEMPLES

1. LET the foundations of those works be dug from a solid site and to a solid base if it can be found, as much as shall seem proportionate to the size of the work; and let the whole site be worked into a structure as solid as possible. And let walls be built, upon the ground under the columns, one-half thicker than the columns are to be, so that the lower portions are stronger than the higher; and these are called the *stereobate*,³ for they receive the loads. And let not the projections of the base mouldings proceed beyond the bed. Further, the thickness of the wall is to be kept above in the same manner. The spaces between the columns are to be arched over, or made solid by being rammed down, so that the columns may be held apart.

2. But if a solid foundation is not found, and the site is loose earth right down, or marshy, then it is to be excavated and cleared and re-made with piles⁴ of alder or of olive or charred oak, and the piles are to be driven close together by machinery, and the intervals between are to be filled with charcoal.

³ The platform on which the columns rest.

⁴ Piles at Ravenna, II. ix. 11.

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palorum, et tunc structuris solidissimis fundamenta
impleantur. Extructis autem fundamentis ad libra-
3 mentum stylobatae sunt conlocandae. Supra stylo-
batas columnae disponendae, quemadmodum supra
scriptum est, sive in pycnostylo, quemadmodum
pycnostyla, sive systylo aut diastylo aut eustylo,
quemadmodum supra scripta sunt et constituta. In
araeostylis enim libertas est quantum cuique libet
constituendi. Sed ita columnae in peripteris conlo-
centur, uti, quot¹ intercolumnia sunt in fronte,
totidem bis intercolumnia fiant in lateribus; ita enim
erit duplex longitudo operis ad latitudinem. Nam-
que qui columnarum duplicationes fecerunt, erravisse
videntur, quod unum intercolumnium in longitudine
4 plus quam oporteat procurrare videtur. Gradus in
fronte constituendi ita sunt, uti sint² semper in pares;
namque cum dextro pede primus gradus ascendatur,
item in summo templo primus erit ponendus. Crassi-
tudines autem eorum graduum ita finiendas censeo,
ut neque crassiores dextante³ nec tenuiores dodrante
sint conlocatae; sic enim durus non erit ascensus.
Retractationes autem graduum nec minus quam ses-
quipedales nec plus quam bipedales faciendae videntur.
Item si circa aedem gradus futuri sunt, ad eundem
5 modum fieri debent. Sin autem circa aedem ex
tribus lateribus podium faciendum erit, ad id con-
stituatur, uti quadrae, spirae, trunci, coronae, lysis
ad ipsum stylobatam, qui erit sub columnarum⁴

¹ quod *H.*

² sunt *G*: sint *H.*

³ dextante *G*: extantae *H* ? xtante *Gr.*

⁴ columnarum *Rode*: columna *H.*

¹ The stylobate is that part of the platform or stereobate on which the columns are erected.

BOOK III. c. iv.

Then the foundations are to be filled with very solid structures. The foundations being built to a level, the stylobates¹ are to be laid. 3. Above the stylobates the columns are to be erected as described above; whether in pycnostyle (as are the pycnostyle temples), or in systyle, or diastyle or eustyle, as it has been described and determined above. For in araeostyle there is freedom to determine as everybody pleases. But let the columns be so disposed in peripteral temples that the intercolumniations on the sides are twice as many as on the front. For then the length of the work will be twice the breadth. For those who made double the number of the columns seem to be at fault because in the length one more intercolumniation than is necessary seems to occur. 4. The steps are to be so placed in front that they are always of an uneven number. For since the first step is ascended on the right foot, the right foot must also be set on the top of the temple steps. And the risers of the steps must be of such dimensions that they are neither deeper than ten inches nor shallower than nine. For thus the ascent will not be hard. But the treads of the steps, it seems, should be made not less than eighteen inches or more than two feet. Also, if steps are to be round the temple, they ought to be made after the same measure. 5. But if a platform is to be made round the temple on three sides, it is to be planned in such a way² that the plinths, bases, dados, cornices and cymatium conform to the pedestal which is under

² These parts of the pedestal have a certain correspondence to the parts of the column and entablature.

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spiris, convenient. Stylobatam ita oportet exaequari, uti habeat per medium adiectionem per scamillos inpaes; si enim ad libellam dirigetur, alveolatum oculo videbitur. Hoc autem, ut scamilli ad id convenientes fiant, item in extremo libro forma et demonstratio erit descripta.

V

- 1 His perfectis in suis locis spirae conlocentur, eaeque ad symmetriam sic perficiantur, uti crassitudo cum plintho sit columnae ex dimidia crassitudine proiecturamque, quam Graeci *εκφοραν*¹ vocitant, habeant sextantem; ita tum lata et longa erit columnae
- 2 crassitudinis unius et dimidia. Altitudo eius, si atticurges erit, ita dividatur, ut superior pars tertia parte sit crassitudinis columnae, reliquum plintho relinquatur. Dempa plintho reliquum dividatur in partes quattuor, fiatque superior torus [quartae; reliquae tres aequaliter dividantur, et una sit inferior torus,]² altera pars cum suis quadris scotia, quam
- 3 Graeci *trochilon*³ dicunt. Sin autem ionicae erunt faciendae, symmetriae earum sic erunt constituendae, uti latitudo spirae quoqueversus sit columnae crassitudinis adiecta crassitudine quarta et octava. Altitudo ita uti atticurges; ita ut eius plinthos; reliquumque praeter plinthum, quod erit tertia⁴ pars crassitudinis columnae, dividatur in partes septem:

¹ *Graecis literis primum servatis = ecphoran H.*

² quartae . . . torus *G: om. H.*

³ trochilon *H.* ⁴ erit tertia *Joc: ei ad tertia H.*

¹ *Scamillus* seems to mean the riser or height of a step.

² Plate C. ³ Refers probably to the torus of the base.

BOOK III. c. iv.—c. v.

the bases of the columns. The stylobate must be so levelled that it increases towards the middle with unequal risers¹; for if it is set out to a level it will seem to the eye to be hollowed. The method of making the risers suitable to this will be set out with a figure and demonstration at the end of the book.

CHAPTER V

ON THE IONIC ORDER²

1. WHEN this is done, let the bases be put in position, and let them be so finished in proportion that the thickness with the plinth amounts to half the thickness of the column, and have a projection (which the Greeks call *ecphora*) of one-sixth.³ The bases will be one and a half thicknesses of a column, front and side. 2. The height, if it is to be an Attic base, is to be thus divided: that the upper part is to be one-third of the thickness of the column, and the remainder left to the plinth. Taking the plinth away, the remainder is to be divided into four parts, and the upper torus is to be one-fourth: the remaining three-fourths are to be equally divided so that one is the lower torus⁴ and the other the scotia⁵ (which the Greeks call *trochilus*) with its fillets. 3. But if the bases are to be Ionic, their proportions are to be so fixed that the breadth of the base each way is one and three-eighths of the thickness of a column. The height is to be like the Attic base; so also its plinth. The remainder beside the plinth, which will be the third part of the column's diameter, is to be divided into

¹ A convex moulding.

² A hollow moulding.

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inde trium partium torus qui est in summo; reliquae quattuor partes dividendae sunt aequaliter, et una pars fiat cum suis astragalis et supercilio superior trochilus, altera pars inferiori¹ trochilo relinquatur; sed inferior maior apparebit, ideo quod habebit ad extremam plinthum² proiecturam. Astragali faciendi sunt octavae partis trochili; proiectura erit spirae pars octava et sexta decuma pars³ crassitudinis columnae.

4 Spiris perfectis et conlocatis columnae sunt medianae in pronao et postico ad perpendicularum medii centri conlocandae, angulares autem quaeque e regione earum futura sunt in lateribus aedis dextra ac sinistra, uti partes interiores, quae ad parietes cellae spectant, ad perpendicularum latus habeant conlocatum, exteriores autem partes uti dicant se earum contracturam. Sic enim erunt figurae compositionis aedium contractura eius taliratione exactae.

5 Scapis columnarum statutis capitulorum ratio si pulvinata erunt, his symmetriis conformabuntur, uti, quam crassus imus scapus fuerit addita octava decuma parte scapi, abacus habeat longitudinem et latitudinem; crassitudinem cum volutis eius dimidiam. Recedendum autem est ab extremo abaco in interiorem partem frontibus volutarum parte duodevicensima et eius dimidia. Tunc crassitudo dividenda est in partes novem et dimidiam, et secundum abacum in quattuor partibus volutarum

¹ inferiori *G*: inferior *H*.

² plinthum *G*: plinthuum *H*. ³ decuma a pars *H*.

¹ Rounded fillet.

² Lit. "so as to declare themselves to be a contraction of the others."

³ These adjustments characterise the whole of the Parthenon.

BOOK III. c. v.

seven parts: of these the torus at the top is to be three parts; the remaining four are to be equally divided; one half to the upper hollow with its astragals¹ and top moulding, the other half is to be left to the lower trochilus; but the lower will seem greater because it will have a projection to the edge of the plinth. The astragals are to be one-eighth part of the scotia. The projection of the base will be three-sixteenths of the thickness of the column.

4. When the bases are complete and in position, the middle columns in front and at the back are to be set up to a perpendicular, but the corner columns and those which are in line with them on the flanks of the temple right and left are to be set up so that the inside parts which look to the sanctuary, have their faces perpendicular, but the outside parts so as to declare their diminution.² In this way the intention of the design of the temple will be completed by such contraction.³

5. When the shafts of the columns are fixed, the proportions of the Ionic capitals⁴ are to be conformed to these symmetries: namely, that, adding the eighteenth part to the thickest part of the shaft, the abacus may find its length and breadth; the height of the capital with the volutes, half of that. There must be a set-back from the edge of the abacus inwards on the front of the volutes of an eighteenth part and a half. Then the height of the capital is to be divided into nine and a half parts, and lines (which are called *cathetoe*) are to be let fall down the abacus, at the four corners of the

⁴ See illustration.

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secundum extremi abaci quadram lineae dimittendae, quae cathetoe dicuntur. Tunc ex novem partibus et dimidia una pars et dimidia abaci crassitudo relinquatur, reliquae octo volutis constituentur.

- 6 Tunc ab linea quae secundum abaci extremam partem dimissa erit, in interiorem partem <alia> recedat unius et dimidiatæ partis latitudine. Deinde hae lineae dividantur ita, ut quattuor partes et dimidia sub abaco reliquatur. Tunc in eo loco, qui locus dividit quattuor et dimidiam et tres et dimidiam partem, centrum oculi; signeturque ex eo centro rotunda circinatio tam magna in diametro, quam una pars ex octo partibus est. Ea erit oculi magnitudine, et in ea catheto¹ respondens diametros agatur. Tunc ab summo sub abaco inceptum in singulis tetrantorum actionibus dimidiatum oculi spatium minuatur, doneque² in eundem tetrantem
- 7 qui est sub abaco, veniat.³ Capituli autem crassitudo sic est facienda, ut ex novem partibus et dimidia tres partes praependeant infra astragalum summi scapi; cymatio, adempto⁴ abaco et canali, reliqua sit pars. Proiectura autem cymatii habet extra abaci quadram oculi magnitudinem. Pulvinorum baltei abaco hanc habeant proiecturam, uti circini centrum unum cum sit positum in capituli tetrante et alterum deducatur ad extremum cymatium, circumactum balteorum extremas partes tangat. Axes volutarum nec crassiores sint quam oculi magnitudo, volutaeque ipsae

¹ catheto *Joc* : cathecton *H*.

² doneque *Lachm* : denique *H*.

³ qui est sub abconveniat *H*.

⁴ adempto *ed* : adepto *H*.

¹ See figure.

BOOK III. c. v.

volute, following a perpendicular from the edge of the abacus. Then of nine parts and a half, one part and a half are to be left as the thickness of the abacus, and the remaining eight parts are to be allotted to the volutes. 6. Then within a vertical line which is let fall at the extreme corner of the abacus, let fall another line at the distance of one part and a half. Next let these lines be so divided that four parts and a half are left under the abacus. Then that point which divides the four and a half and the three and a half is the centre of the eye of the volute: and let there be drawn from that centre a complete circle with a diameter of one part out of the eight parts. That will be the magnitude of the eye. Through the centre let there be drawn a vertical diameter. Then, beginning from the top under the abacus, let the radius be successively diminished by half the diameter of the eye in describing the quadrants, until it comes into the quadrant which is under the abacus.¹ 7. Now the height of the capital is to be so arranged that of the nine and a half parts, three parts are below the astragal at the top of the shaft. The remaining part is for the cymatium, when the abacus and channel are taken away. The projection of the cymatium beyond the abacus is to be the size of the eye. Let the bands of the pillows² have the following projection: one point of the compasses is placed in the centre of the eye, and the other point is taken to the top of the cymatium; the circle thus described will mark the furthest part of the pillow band. The axes of the volutes should not be further apart than the diameter of the eye, and the volutes

² *Pulvinus*.

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sic caedantur¹ altitudinis suae duodecimam partem. Haec erunt symmetriae capitulorum, quae² columnae futurae sunt ab minimo ad pedes xxv. Quae supra erunt, reliqua habebunt ad eundem modum symmetrias, abacus autem erit longus et latus, quam crassa columna est ima adiecta parte viii, uti, quo minus habuerit altior columna contractum, eo ne minus habeat capitulum suae symmetriae proiecturam
8 et in altitudine³ suae partis⁴ adiectionem. De volutarum descriptionibus, uti ad circinum sint recte involutae, quemadmodum describantur, in extremo libro forma et ratio earum erit subscripta.

Capitulis perfectis deinde columnarum non ad libellam sed ad aequalem modulum conlocatis, ut, quae adiectio in stylobatis facta fuerit, in superioribus membris respondeat symmetria epistyliorum. Epistyliorum ratio sic est habenda, uti, si columnae fuerint a minima xii pedum ad quindecim pedes, epistylii sit altitudo dimidia crassitudinis imae columnae; item ab xv pedibus ad xx, columnae altitudo demetiatur in partes tredecim, et unius partis altitudo epistylii fiat; item si a xx ad xxv pedes, dividatur altitudo in partes xii et semissem, et eius una pars epistylum in altitudine fiat; item si ab xxv pedibus ad xxx, dividatur in partes xii, et eius una pars altitudo fiat. Item ratam partem ad eundem modum ex altitudine columnarum expediendae sunt altitudines epistylorum.
9 styliorum. Quo altius enim scandit oculi species, non facile persecat aeris crebritatem; dilapsa itaque

¹ sic cedantur *H*.

² capitulorumque *H*.

³ latitudine *rec*: altitudine *H*.

⁴ suae partis *H^c*: repartis *H G*.

BOOK III. c. v.

themselves are to be channelled to the twelfth part of their height. These will be the proportions of capitals when the columns shall be up to twenty-five feet. Those which are more will have their other proportions after the same fashion. The length and breadth of the abacus will be the thickness of the column at its base with the addition of one-ninth: inasmuch as its diminution is less as the height is greater, the capital must not have less addition in projection and height. 8. At the end of the book a diagram and formula will be furnished for the drawing of the volutes so that they may be correctly turned by the compass.

When the capitals are completed they are to be set, not level through the range of columns, but with a corresponding adjustment; so that the architraves in the upper members may correspond to the addition in the stylobates. The proportion of the architraves should be as follows: if the columns are from twelve to fifteen feet, the height of the architrave should be half the thickness of the column at the bottom; from fifteen to twenty feet let the height of the column be divided into thirteen parts, and the height of the architrave be one part; from twenty to twenty-five feet, let the height be divided into twelve parts and a half, and let the architrave be one part of that in height; also from twenty-five to thirty let it be divided into twelve parts, and let the height be made of one part. Thus the heights of the architraves are to be determined in accordance with the height of the columns. 9. For the higher the glance of the eye rises, it pierces with the more difficulty the denseness of the air; therefore it fails owing to the

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- altitudinis spatio et viribus, exstructam incertam modulorum renuntiat sensibus quantitatem. Quare semper adiciendum est rationi supplementum in symmetriarum membris, ut, cum fuerint aut¹ altioribus locis opera aut etiam ipsa colossicoter², habeant magnitudinum rationem. Epistylīi latitudo in imo, quod supra capitulum erit, quanta crassitudo summae columnae sub capitulo erit, tanta fiat ;
- 10 summum, quantum imus scapus. Cymatium epistylīi³ septima parte suae altitudinis est faciendum, et in proiectura tantundem. Reliqua pars praeter cymatium dividenda est in partes XII, et earum trium ima⁴ fascia est facienda, secunda IIII, summa v. Item zophorus supra epistylium quarta parte minus quam epistylium; sin autem sigilla designari oportuerit, quarta parte altior⁵ quam epistylium, uti auctoritatem habeant sculpturae. Cymatium suae altitudinis partis septimae; proiecturae cymatium
- 11 quantum⁶ crassitudo. Supra zophorum denticulus est faciendus tam altus quam epistylīi media fascia⁷; proiectura eius quantum altitudo. Intersectio, quae Graece *metope*⁸ dicitur, sic est dividenda, uti denticulus altitudinis suae dimidiam partem habeat in fronte, cavus autem intersectionis⁹ huius frontis e tribus duas partes; huius cymatium altitudinis eius sextam partem. Corona cum suo cymatio, praeter

¹ ut cum fuerint aut *Joc*: cum fuerint ut aut *H*.

² colossicoter² *Joc*: colossi caetera *H*.

³ cymatium epistylīi *ed*: cymatii epystilīi *H*.

⁴ ima *Polenus*: iam *H*. ⁵ altior *Phil*: altiore *H*.

⁶ quantum *Mar*: quam *H*. ⁷ fascia *Joc*: fastigia *H*.

⁸ metoce *H*. ⁹ intersectionis *G*: -nes *H*.

BOOK III. c. v.

amount and power of the height, and reports to the senses the assemblage of an uncertain¹ quantity of the modules. And so we must always add a supplement to the proportion in the case of the symmetrical parts, so that works which are either in higher positions or themselves more grandiose may have proportionate dimensions. The breadth of the architrave at the bottom where it rests upon the capital should equal the diameter of the top of the column under the capital: the top of the architrave should be as wide as the lower diameter of the shaft. 10. The cymatium² of the architrave should be made one-seventh of its height and the projection of it the same. The remainder apart from the cymatium is to be divided into twelve parts of which the lowest fascia³ is to have three; the second, four; the top, five. The frieze also above the architrave is to be a fourth less than the architrave; but if figures are to be introduced, a fourth higher, so that the carvings may be effective. The cymatium a seventh part of its height; the projection of the cymatium as much as the thickness. 11. Above the frieze the dentil⁴ is to be made as high as the middle fascia of the architrave; its projection as much as its height. The interval, which in Greek is called *metope*,⁵ is to be arranged so that the dentil is half as wide as it is high; the hollow of the interval is two-thirds of the front of the dentil; the cymatium of this, one-sixth its height. The cornice with its cymatium, but without the

¹ Cf. "uncertain images," VII. *pref.* 11.

² See illustration. ³ A plain perpendicular band.

⁴ Small blocks projecting from the lower part of the cornice.

⁵ These are not to be confused with the larger square members which come between the triglyphs of the Doric order.

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- simam, quantum media fascia epistylī; proiectura coronae cum denticulo facienda est, quantum erit altitudo a zophoro ad summum coronae cymatium; et omnino omnes ecphorae venustiore[m] habeant speciem, quae quantum altitudinis ¹ tantundem habeant
- 12 proiecturae. Tympani autem, quod est in fastigio, altitudo sic est facienda, uti frons coronae ab extremis cymatiis tota dimetiatur in partes novem et ex eis una pars in medio cacumine tympani constituatur, dum contra epistylia ² columnarumque hypotrachelia ad perpendicularum respondeant. Coronaeque supra aequaliter imis praeter simas sunt conlocandae. Insuper coronas simae, quas Graeci *epaetidas* ³ dicunt, faciendae sunt altiores octava parte coronarum altitudinis. Acroteria angularia tam alta, quantum est tympanum medium, mediana altiora octava parte quam angularia.
- 13 Membra omnia, quae supra capitula columnarum sunt futura, id est epistylia, zophora, coronae, ⁴ tympana, fastigia, acroteria, inclinanda sunt in frontis suae cuiusque altitudinis parte XII, ideo quod, cum steterimus contra frontes, ab oculo lineae duae si extensae fuerint et una tetigerit imam operis partem, altera summam, quae summam tetigerit, longior fiet. Ita quo longior visus linea in superiorem partem procedit, resupinatam facit eius speciem. Cum autem, uti supra scriptum est, in fronte inclinata

¹ altitudinis *G*: -nes *H*.

² epistylia *Joc*: -lii *H*.

³ epitidas *H* (*corr. Bötticher*).

⁴ coronae *Joc*: corona & *x*.

¹ Moulding above cornice.

² Neckings.

³ Small pedestals on which statues are placed.

BOOK III. c. v.

simas,¹ is to be equal to the middle fascia of the architrave. The projection of the cornice with the dentil is to be made equal to the height from the frieze to the top of the cymatium of the cornice; and generally all projections have a more graceful appearance when they are equal to the height of the feature. 12. The height of the tympanum which is in the pediment is to be such, that the whole front of the cornice from the outside of the cymatia is to be measured into nine parts; and of these one is to be set up in the middle for the summit of the tympanum. The architraves and hypotrachelia² of the columns are vertically under it. The cornices above the tympana are to be made equal to those below, omitting the simae. Above the cornices the simae, which the Greeks call *epaietides*, are to be made higher by one-eighth than the coronae. The angle acroteria³ are to be as high as the middle of the tympanum; the middle ones are to be one-eighth higher than those at the angles.

13. All the features which are to be above the capitals of the columns, that is to say, architraves, friezes, cornices, tympana, pediments, acroteria, are to be inclined towards their fronts by a twelfth part of their height; because when we stand against the fronts, if two lines are drawn from the eye,⁴ and one touches the lowest part of the work, and the other the highest, that which touches the highest, will be the longer. Thus because the longer line of vision goes to the upper part, it gives the appearance of leaning backwards. When however, as written above, the line is inclined to the front, then the

⁴ Optical consideration involves a reference to perspective.

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- fuerit, tunc in aspectu videbuntur esse ad perpendi-
14 culum et normam. Columnarum striae faciendae sunt **xxiiii** ita excavatae, uti norma in cavo striae cum fuerit coniecta, circumacta anconibus striarum dextra ac sinistra tangat acumenque normae circum rotundationem tangendo pervagari possit. Crassitudines striarum faciendae sunt, quantum adiectio in media columna ex descriptione invenietur.
- 15 In simis, quae supra coronam in lateribus sunt aedium, capita leonina sunt scalpenda, disposita <ita>, uti contra columnas singulas primum sint designata, cetera aequali modo disposita, uti singula singulis mediis tegulis respondeant. Haec autem, quae erunt contra columnas, perterebrata sint ad canalem, qui excipit e tegulis aquam caelestem; mediana autem sint solida, uti, quae cadit vis aquae per tegulas in canalem, ne deiciatur per intercolumnia neque transeuntes perfundat,¹ sed quae sunt contra columnas, videantur emittere vomentia ructus aquarum ex ore.

Aedium ionicarum, quam apertissime potui, dispositiones hoc volumine scripsi; doricarum autem et corinthiarum quae sint proportionibus, insequenti libro explicabo.

¹ perfundant *H.*

BOOK III. c. v.

parts will seem vertical and to measure. 14. The flutes of the columns are to be twenty four, hollowed out in such a way that if a set square is placed in the hollow of a flute and moved round its ends, it will touch the fillets on the right and left, and the point of the square will touch the curve as it moves round. The width of the flutes is to be altered so as to suit the addition produced by the swelling¹ of the column. 15. On the mouldings, which are above the cornice on the sides of temples, lions' heads are to be carved, and arranged firstly so as to be set over against the tops of the several columns; the others at equal intervals so as to answer to the middle of the roof tiling. But these which will be against the columns are to be pierced for a gutter which takes the rain-water from the tiles. The intervening heads are to be solid so that the water which falls over the tiles into the gutter, may not fall down through the inter-columniations upon the passers by. But those which are against the columns are to seem to vomit and let fall streams of water from their mouths.

In this book I have written about the arrangements of Ionic temples as clearly as I could: I will unfold in the next book the proportions of Doric and Corinthian temples.

¹ Entasis; see above c. iii. 13.

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BOOK IV

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LIBER QUARTUS

- 1 Cum animadvertissem, imperator, plures de architectura praecepta voluminaque commentariorum non ordinata sed incepta, uti particulas, errabundos ¹ reliquisse, dignam et utilissimam rem putavi antea disciplinae corpus ad perfectam ordinationem perducere et praescriptas in singulis voluminibus singulorum generum qualitates explicare. Itaque, Caesar, primo volumine tibi de officio eius et quibus eruditum esse rebus architectum oporteat, exposui. Secundo de copiis materiae, e quibus aedificia constituuntur, disputavi; tertio autem de aedium sacrarum dispositionibus et de earum generum varietate quasque et quot ² habeant species earumque
- 2 quae sunt in singulis generibus distributiones. Ex tribus generibus quae subtilissimas haberent proportionibus modulorum quantitates ionici generis moribus, docui; nunc hoc volumine de doricis corinthiisque constitutis (et) ³ omnibus dicam eorumque discrimina et proprietates explicabo.

¹ errabundas *Joc*: -dos *II*.

³ *om. Gr.*

² quod *II*.

BOOK IV

PREFACE

1. WHEN I perceived, your Highness, that many persons had stated the rules of Architecture, and had written commentaries casually, not set in due order but merely inchoate (like atoms) I thought it a worthy and most useful task first of all to reduce the encyclopedia of architecture to a perfect order, and in the several books to explain the qualities¹ of the several objects assigned to them. Therefore, Caesar, in the first book I expounded the function of the architect and the subjects in which he should be trained; in the second I discussed the supplies of the materials, of which buildings are constructed; in the third, the arrangements of temples, their different kinds, how many styles of design there were, and the details which belong to them severally. 2. Of the three orders, I taught, in reference to the Ionic order, those rules which, by the use of proportion, furnish the most exact adjustment of the modules. In this book I will proceed to speak of the Doric and Corinthian orders generally, their distinctions and properties.

¹ As distinct from quantity.

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I

- 1 COLUMNAE corinthiae praeter capitula omnes symmetrias habent uti ionicae, sed capitulorum altitudines efficiunt eas pro rata excelsiores et graciliores, quod ionici capituli altitudo tertia pars est crassitudinis columnae, corinthii¹ tota crassitudo scapi. Igitur quod duae partes e crassitudine corinthiarum² adiciuntur, efficiunt excelsitate speciem earum
- 2 graciliorem. Cetera membra quae supra columnas inponuntur, aut e doriceis symmetriis aut ionicis moribus in corinthiis columnis conlocantur, quod ipsum corinthium genus propriam³ coronarum reliquorumque ornamentorum non habuerat institutionem, sed aut e triglyphorum⁴ rationibus mutuli in coronis et epistyliis guttae dorico more disponuntur, aut ex ionicis institutis zophoroe sculpturis ornat
- 3 cum denticulis et coronis distribuuntur. Ita e generibus duobus capitulo interposito tertium genus in operibus est procreatum. E columnarum enim formationibus trium generum factae sunt nominationes, dorica, ionica, corinthia, e quibus prima et antiquitus dorica est nata.

Namque Achaia Peloponnesoque tota Dorus, Hellenos⁵ et Phthiados⁶ nymphae filius, regnavit,

¹ corinthii *Joc* : -thie *H*.

² corinthiarum *Schn* : -orum *H*.

³ propria *H*. ⁴ & triglyphorum *H*.

⁵ Hellenos *Polenus* : helenidos *H*.

⁶ Exptidos *H* : Phthiados *Gr*. Eur. *Hec*. 451.

¹ The Porticus Octavia was the first work built in the Corinthian style at Rome, in 168 B.C., and was also called Porticus Corinthia. Lanciani *RE* 469, Platner 426.

BOOK IV. c. I.

CHAPTER I

ON THE CORINTHIAN CAPITAL

1. CORINTHIAN¹ columns have all their proportions like the Ionic, with the exception of their capitals. The height of the capitals renders them proportionately higher and more slender, because the height of the Ionic capital is one third of the thickness of the column, that of the Corinthian is the whole diameter of the shaft. Therefore because two-thirds of the diameter of the Corinthian columns are added to the capitals they give an appearance of greater slenderness owing to the increase in height. 2. The remaining features which are fixed above the columns are placed upon them in accordance either with Doric proportions or in the Ionic manner; because the Corinthian order has not separate rules for the cornices and the other ornaments, but, on the one hand, the mutules² in the cornices and the guttae in the architraves, are disposed in the Doric fashion; or, on the other hand following the Ionic arrangement, the friezes are adorned with carving and are combined with dentils and cornices. 3. Thus from the two orders, a third is produced by the introduction of a new capital. From the formation of the columns, come the names of the three styles, Doric, Ionic, Corinthian; of which the Doric came first and from early ages.³

For in Achaea and over the whole Peloponnese, Dorus, the son of Hellen and the nymph

² Mutule = projecting bracket.

³ It is anticipated in the buildings of Cnossus in Crete; see Plate E.

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isque Argis, vetusta civitate, Iunonis templum aedificavit, eius generis fortuito formae fanum, deinde isdem generibus in ceteris Achaiae civitatibus, cum etiamnum non esset symmetriarum ratio nata.

4 Postea autem quam Athenienses ex responsis Apollinis Delphici, communi consilio totius Hellados, xiii colonias uno tempore in Asiam deduxerunt ducesque in singulis coloniis constituerunt et summam imperii potestatem Ioni, Xuthi¹ et Creusae² filio, dederunt, quem etiam Apollo Delphis suum filium in responsis est professus, isque eas colonias in Asiam deduxit et Cariae fines occupavit ibique civitates amplissimas constituit Ephesum, Miletum, Myunta³ (quae olim ab aqua est devorata; cuius sacra et suffragium Milesiis⁴ Iones adtribuerunt), Prienen,⁵ Samum, Teon, Colophona, Chium, Erythras,⁶ Phocaeam,⁷ Clazomenas,⁸ Lebedon, Meliten⁹ (haec Melite propter civium adrogantiam ab his civitatibus bello indicto communi consilio est sublata; cuius loco postea regis Attali et Arsinoes beneficio Zmyrnaeorum civitas inter Ionas est recepta): hae civitates, cum Caras et Lelegas eiecissent, eam terrae regionem a duce suo Ione appellaverunt Ioniam ibique deorum immortalium templa constituentes coeperunt fana

5 aedificare. Et primum Apollini¹⁰ Panionio¹¹ aedem,

¹ ionix uthi *H.*

² Creusae *Joc*: ereuso *H.*

³ myanta *H.*

⁴ milesius *H.*

⁵ prenem *H.*

⁶ erytras *H.*

⁷ phoea *H.*

⁸ glazomenum *H.*

⁹ meletenis *H.*

¹⁰ appollini *H.*

¹¹ Panionio *Joc*: pandionio *H.*

¹ Euripides' play *Ion* is probably alluded to here. Vitruvius quotes from his *Phaethon* and has preserved an otherwise unknown fragment Book IX. i. 13.

² *Aqua* refers to the encroachment of the sea.

BOOK IV. c. 1.

Phthia was king; by chance he built a temple in this style at the old city of Argos, in the sanctuary of Juno, and, afterwards, in the other cities of Achaea after the same style, when as yet the determination of the exact proportions of the order had not begun. 4. Afterwards the Athenians, in accordance with the responses of Apollo, and by the general consent of all Greece, founded thirteen colonies in Asia at one time. They appointed chiefs in the several colonies, and gave the supreme authority to Ion, the son of Xuthus and Creusa (whom Apollo, in his responses at Delphi, had declared to be his son).¹ He led the colonies into Asia and seized the territory of Caria. There he established the large cities of Ephesus, Miletus, Myus² (of which, being swallowed up in marshy ground, the worships and vote in the League were transferred to Miletus), Priene, Samos, Teos, Colophon, Chios, Erythrae, Phocaea, Clazomenae, Lebedos, Melite. Against Melite, because of the insolence of its citizens, war was declared by the other cities, and it was destroyed by general consent. In its place, afterwards,³ the city of the Smyrnaeans was received among the Ionians by the kindness of King Attalus and Arsinoe. 5. These cities drove out the Carians and Leleges and named that region of the earth Ionia from their leader Ion, and establishing there sanctuaries of the immortal gods, they began to build temples in them. First, to Panionian⁴ Apollo they established a temple

¹ 3rd century B.C.

⁴ The Panionium at Mycale was dedicated to Neptune (Poseidon). There was another Panionium dedicated to Apollo C. I. A. III. 175.

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uti viderant in Achaia, constituerunt et eam Doricam appellaverunt, quod in Dorieon¹ civitatibus primum
6 factam eo genere viderunt. In ea aede cum voluissent columnas conlocare, non habentes symmetrias earum et quaerentes quibus rationibus efficere possent, uti et ad onus ferendum essent idoneae et in aspectu probatam haberent venustatem, dimensi sunt virilis pedis vestigium et id retulerunt in altitudinem. Cum invenissent pedem sextam partem esse altitudinis in homine, item in columnam transtulerunt et, qua crassitudine fecerunt basim scapi, tanta sex cum capitulo in altitudinem extulerunt. Ita dorica columna virilis corporis proportionem et firmitatem et venustatem in aedificiis praestare coepit.

7 Item postea Dianae constituere aedem, quaerentes novi generis speciem isdem vestigiis ad muliebrem transtulerunt gracilitatem, et fecerunt primum columnae crassitudinem octava parte, ut haberet speciem excelsiorem. Basi spiram subposuerunt pro calceo, capitulo volutas uti capillamento concrispatos cincinnos praependentes dextra ac sinistra conlocaverunt et cymatiis et encarpis pro crinibus dispositis frontes ornaverunt truncoque toto strias² uti stolarum rugas³ matronali more dimiserunt, ita duobus discriminibus columnarum inventionem, unam virili sine
8 ornatu nudam speciem, alteram muliebri. Subtilitateque iudiciorum progressi et gracilioribus modulis delectati septem crassitudinis diametros in altitudinem columnae doricae, ionicae novem constituerunt. Id autem quod Iones fecerunt primo, Ionicum est nominatum.

¹ Dorieon *Joc* : dorichon *H*.

² istrias *H*.

³ rugas *G* : rugus *H*.

BOOK IV. c. I.

as they had seen in Achaia. Then they called it Doric because they had first seen it built in that style. 6. When they wished to place columns in that temple, not having their proportions, and seeking by what method they could make them fit to bear weight, and in their appearance to have an approved grace, they measured a man's footstep and applied it to his height. Finding that the foot was the sixth part of the height in a man, they applied this proportion to the column. Of whatever thickness they made the base of the shaft they raised it along with the capital to six times as much in height. So the Doric column began to furnish the proportion of a man's body, its strength and grace.¹

7. Afterwards also seeking to plan a temple of Diana in a new kind of style, they changed it to a feminine slenderness with the same measurement by feet. And first they made the diameter of the column the eighth part of it, so that it might appear taller. Under the base they placed a convex moulding as if a shoe; at the capital they put volutes, like graceful curling hair, hanging over right and left. And arranging cymatia and festoons in place of hair, they ornamented the front, and, over all the trunk (*i.e.* the shaft), they let fluting fall, like the folds of matronly robes; thus they proceeded to the invention of columns in two manners; one, manlike in appearance, bare, unadorned; the other feminine. 8. Advancing in the subtlety of their judgments and preferring slighter modules, they fixed seven measures of the diameter for the height of the Doric column, nine for the Ionic. This order because the Ionians made it first, was named Ionic.

¹ This theory is of late origin.

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- Tertium vero, quod Corinthium dicitur, virginalis ¹ habet gracilitatis imitationem, quod virgines propter aetatis teneritatem gracilioribus membris figuratae
9 effectus recipiunt in ornatu venustiores. Eius autem capituli prima inventio sic memoratur esse facta. Virgo civis Corinthia iam matura nuptiis implicata morbo decessit. Post sepulturam eius, quibus ea virgo viva poculis delectabatur, nutrix collecta et composita in calatho pertulit ad monumentum et in summo conlocavit et, uti ea permanerent diutius subdiu, tegula texit. Is calathus fortuito supra acanthi radicem fuerit conlocatus. Interim pondere pressa radix acanthi ² media folia et cauliculos circum vernum tempus profudit, cuius cauliculi secundum calathi latera crescentes et ab angulis tegulae ponderis necessitate expressi flexuras in extremas partes
10 volutarum facere sunt coacti. Tunc Callimachus qui propter elegantiam et subtilitatem artis marmoreae ab Atheniensibus *catatechnos* fuerat nominatus, praeteriens hoc monumentum animadvertit eum calathum et circa foliorum nascentem teneritatem, delectatusque genere et formae novitate ad id exemplar columnas apud Corinthios fecit symmetriasque constituit; ex eo in operis perfectionibus
11 Corinthii generis distribuit rationes. Eius autem capituli symmetria sic est facienda, uti, quanta fuerit crassitudo imae columnae, tanta sit altitudo capituli cum abaco. Abaci latitudo ita habeat rationem, ut, quanta fuerit altitudo, tanta duo sint diagonia ab

¹ virginales *H.*

² achanti *H.*

BOOK IV. c. I.

But the third order, which is called Corinthian,¹ imitates the slight figure of a maiden; because girls are represented with slighter dimensions because of their tender age, and admit of more graceful effects in ornament. 9. Now the first invention of that capital is related to have happened thus. A girl, a native of Corinth, already of age to be married, was attacked by disease and died. After her funeral, the goblets which delighted her when living, were put together in a basket by her nurse, carried to the monument, and placed on the top. That they might remain longer, exposed as they were to the weather, she covered the basket with a tile. As it happened the basket was placed upon the root of an acanthus. Meanwhile about spring time, the root of the acanthus, being pressed down in the middle by the weight, put forth leaves and shoots. The shoots grew up the sides of the basket, and, being pressed down at the angles by the force of the weight of the tile, were compelled to form the curves of volutes at the extreme parts. 10. Then Callimachus, who for the elegance and refinement of his marble carving was nick-named *catatechnos* by the Athenians, was passing the monument, perceived the basket and the young leaves growing up. Pleased with the style and novelty of the grouping, he made columns for the Corinthians on this model and fixed the proportions. Thence he distributed the details of the Corinthian order throughout the work. 11. The proportions of the capital are to be arranged thus. The height of the capital with the abacus is to equal the diameter of the bottom of the column. The width of the abacus is to be so proportioned: the diagonal lines from angle to angle are to equal twice

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angulo ad angulum; spatia enim ita iustas habebunt frontes quoquoersus latitudinis. Frontes simentur introrsus ab extremis angulis abaci suae frontis latitudinis nona.¹ Ad imum capituli tantam habeat crassitudinem, quantam habet summa columna praeter apothesis et astragalum. Abaci² crassitudo
12 septima capituli altitudinis. Dempta abaci crassitudine dividatur reliqua pars in partes tres, e quibus una imo folio detur; secundum folium mediam altitudinem teneat; coliculi³ eandem habeant altitudinem, e quibus folia nascuntur proiecta, uti excipiant quae ex coliculis natae procurrun ad extremos angulos volutae; minoresque helices intra suum medium, qui est in abaco; flores subiecti scalpantur. Flores in quattuor partibus, quanta erit abaci crassitudo, tam magni formentur. Ita his symmetriis corinthia capitula suas habebunt exactiones.

Sunt autem, quae isdem columnis inponuntur, capitulorum genera variis vocabulis nominata, quorum nec proprietates symmetriarum nec columnarum genus aliud nominare possumus, sed ipsorum vocabula traducta et commutata ex corinthiis et pulvinatis et doricis videmus, quorum symmetriae sunt in novarum scalpturarum translatae subtilitatem.

¹ nona *Joc*: non *H*.

² astragalum. Abaci *Joc*: abaci astragalum *H*.

³ coliculi *H*.

BOOK IV. c. I.

the height of the capital. Thus the front elevations in every direction, will have the right breadth. Let the faces be curved inward from the extreme angles of the abacus the ninth part of the breadth of the face. At the lowest part, let the capital have the diameter of the top of the column, excluding the curving away of the column into the capital, and the astragal.¹ The thickness of the abacus is one seventh of the height of the capital. 12. Taking away the thickness of the abacus, let the remainder be divided into three parts, of which let one be given to the lowest leaf. Let the second leaf have two thirds. Let the stalks have the same height, and let leaves arise from these, projecting to receive the volutes which rise from the stalks and run out to the extreme angles. Let smaller spirals be carved running up to the flower which is in the middle of the abacus. On the four sides let flowers be carved, their width being equal to the height of the abacus. With these proportions, Corinthian capitals will have their appropriate execution.

There are other ² kinds of capitals variously named which are placed upon these same columns. We cannot name their special proportions nor the style of the columns in any other manner. We observe that even their names are transferred and changed from the Corinthian, Pulvinate and Doric styles, the proportions of which are transferred to the refinements of these novel sculptures.

¹ See Plate D.

² The varieties of the Corinthian capital passed by easy stages to the Gothic capital. Timgad in the second cent. A.D. shows many forms. The Byzantine sculptors gave a convex form to the Corinthian capital as at San Vitale, Ravenna.

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II

- 1 QUONIAM autem de generibus columnarum origines et inventiones supra sunt scriptae, non alienum mihi videtur isdem rationibus de ornamentis eorum, quemadmodum sunt prognata et quibus principiis et originibus inventa, dicere. In aedificiis omnibus insuper conlocatur materiatio variis vocabulis nominata. Ea autem uti in nominationibus, ita in res varias habet utilitates. Trabes enim supra columnas et parastaticas et antas ponuntur; in contignationibus tigna et axes; sub tectis, si maiora spatia sunt, et transtra et capreoli,¹ si commoda, columnen, et cantherii prominentes ad extremam suggrundationem; supra cantherios templa; deinde insuper sub tegulas asseres ita prominentes, uti parietes protecturis
- 2 eorum tegantur. Ita unaquaeque res et locum et genus et ordinem proprium tuetur. E quibus rebus et a materiatura fabrilis in lapideis et marmoreis aedium sacrarum aedificationibus artifices dispositiones eorum scalpturis sunt imitati et eas inventiones persequendas putaverunt. Ideo, quod antiqui fabri quodam in loco aedificantes, cum ita ab interioribus parietibus ad extremas partes tigna prominentia habuissent conlocata, inter tigna struxerunt supraque coronas et fastigia venustiore specie fabrilibus operibus ornaverunt, tum proiecturas tignorum, quantum

¹ capreoli *G*: -lis *H*.

¹ Cf. Book I. i. 5.

² The influence of wood details upon stonework is undoubted.

BOOK IV. C. II.

CHAPTER II

ON THE DETAILS OF THE ORDERS

1. Now since the origins and discovery of the orders of columns have been described above, it does not seem foreign to my purpose if I speak in the same way about their ornaments: how they came about, and from what principles and origins they were invented.¹ In all buildings timbering,² called by various names, is used in the upper parts; as in name, so in practice, it has uses for various things. Beams are placed on columns, pilasters and responds. In floors there are joists and planks. Under roofs, if the spans are considerable, both cross pieces and stays; if of moderate size, a ridge piece with rafters projecting to the edge of the eaves. Above the principal rafters, purlins; then above, under the tiles, rafters which overhang so that the walls are covered by the eaves.³ 2. So each scantling preserves its proper place and style and arrangement. In view of these things and of carpenter's work generally, craftsmen imitated such arrangements in sculpture when they built temples of stone and marble. For they thought these models worth following up. Thus workmen of old, building in various places, when they had put beams reaching from the inner walls to the outside parts, built in the spaces between the beams; above through their craftsmanship, they ornamented the cornices and gables with a more graceful effect. Then they cut off the projections of the beams, as far as they came

³ *Protectura* for eaves is probably right: *protecum* is used in this sense.

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eminebant, ad lineam et perpendicularum parietum praesecuerunt, quae species cum invenusta is visa esset, tabellas ita formatas, uti nunc fiunt triglyphi, contra tignorum praecisiones in fronte fixerunt et eas cera caerulea depinxerunt, ut praecisiones tignorum tectae non offenderent visum ita divisiones tignorum tectae triglyphorum dispositionem et inter tigna metoparum¹ habere in doricis operibus coeperunt. Postea alii in aliis operibus ad perpendicularum triglyphorum cantherios prominentes proiecerunt eorumque proiecturas simaverunt. Ex eo, uti tignorum dispositionibus triglyphi, ita e cantheriorum proiecturismetulorum sub coronulis² ratio est inventa. Ita fere in operibus lapideis et marmoreis mutuli inclinatis sculpturis deformantur, quod imitatio est cantheriorum; etenim necessario propter stillicidia proclinati conlocantur. Ergo et triglyphorum et mutulorum in doricis operibus ratio ex³ ea imitatione inventa est.

4 Non enim, quemadmodum nonnulli errantes dixerunt fenestrarum imagines esse triglyphos, ita potest esse, quod in angulis contraque tetrantes columnarum triglyphi constituuntur, quibus in locis omnino non patitur res fenestras fieri. Dissolvuntur enim angulorum in aedificiis iuncturae, si in is fenestrarum fuerint lumina relictas. Etiamque ubi nunc triglyphi constituuntur, si ibi luminum spatia fuisse iudicabuntur, isdem rationibus denticuli⁴ in ionicis fenestrarum occupavisse loca videbuntur. Utraque⁵ enim, et inter denticulos et inter triglyphos quae sunt intervalla, metopae⁶ nominantur. *Opas* enim Graeci

¹ intertignum et oparum *H*: inter tigna *Gr*.

² coronulis *H*: cf. *Vulg*. ³ ex *G*: & *H*.

⁴ denticuli *ed. Fl*: denticulis *H*.

BOOK IV. c. II.

forward, to the line and perpendicular of the walls. But since this appearance was ungraceful, they fixed tablets shaped as triglyphs now are, against the cut-off beams, and painted them with blue wax, in order that the cut-off beams might be concealed so as not to offend the eyes. Thus in Doric structures, the divisions of the beams being hidden began to have the arrangement of the triglyphs, and, between the beams, of metopes. 3. Subsequently other architects in other works carried forward over the triglyphs the projecting rafters, and trimmed the projections. Hence just as triglyphs came by the treatment of the beams, so from the projections of the rafters the detail of the mutules under the cornices was invented. Thus generally in buildings of stone and marble the mutules are modelled with sloping carving; and this imitates the rafters. For they are necessarily put sloping because of the rainfall. Therefore in the Doric style the detail both of the triglyphs and of the mutules arose from this imitation of timber work.

4. For it cannot be that triglyphs are representations of windows (as some have mistakenly said). For triglyphs are placed at the angles of the front, and over the centre of columns; where generally it is impossible for windows to be made. For the bond at the angles of buildings is destroyed, if window lights are left there. And also if window lights are considered to have been where now triglyphs are placed, in the same way dentils in Ionic buildings will seem to have taken the place of windows. For the intervals, which are both between dentils and between triglyphs, are called *metopae*. For the

⁵ *utraque Joc : utrique H.*

⁶ *metophe H.*

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tignorum cubicula et asserum appellant, uti nostri ea cava¹ columbaria. Ita quod inter duas opas est intertignum,² id *metope* est apud eos nominata.

- 5 Ita uti autem in doricis triglyphorum et mutulorum est inventa ratio, item in ionicis denticulorum constitutio propriam in operibus habet rationem, et quemadmodum mutuli cantheriorum proiecturae ferunt³ imaginem, sic in ionicis denticuli⁴ ex projecturis asserum habent imitationem. Itaque in graecis operibus nemo sub mutulo denticulos constituit; non enim possunt subtus cantherios asseres esse. Quod ergo supra cantherios et templa in veritatem debet esse conlocatum, id in imaginibus si infra constitutum fuerit, mendosam habebit operis rationem. Etiam quod antiqui non probaverunt, neque instituerunt in fastigiis <mutulos aut>⁵ denticulos fieri sed puras coronas, ideo quod nec cantherii nec asseres contra fastigiorum frontes distribuuntur nec possunt prominere, sed ad stillicidia⁶ proclinati conlocantur. Ita quod non potest in veritate fieri, id non putaverunt in imaginibus factum posse certam
6 rationem habere. Omnia enim certa proprietate et a veris naturae deducta⁷ moribus transduxerunt in operum perfectiones, et ea probaverunt, quorum explicationes in disputationibus rationem possunt habere veritatis. Itaque ex eis originibus symmetrias et proportionem uniuscuiusque generis constitu-

¹ cava *rec*: caba *H*.

² opas est intertignum *Joc*: ophas et intertignum *H*.

³ ferunt *G*: fuerunt *H*.

⁴ denticuli ex *Joc*: denticulis et *H*.

⁵ *add. Phil.* ⁶ stillicidia *H*.

⁷ deducta *rec*: -tis *H*.

¹ This rule is specially insisted on by critics of architecture.

BOOK IV. c. II.

Greeks give the name of *opae* to the beds of beams and rafters; as our people call them hollow mortices. So the space between the two *opae* is called *metopa* among the Greeks.

5. In the Doric order, the detail of the triglyphs and mutules was invented with a purpose. Similarly in Ionic buildings, the placing of the dentils, has its appropriate intention. And just as in the Doric order the mutules have been the representation of the projecting principal rafters, so, in the case of Ionic dentils, they also imitate the projection of the ordinary rafters. Therefore in Greek works no one puts dentils under a mutule.¹ For ordinary rafters cannot be put beneath principals. For if what ought to be placed above principals and purlins in reality is placed below them in the imitation, the treatment of the work will be faulty.² Further, as to the ancients neither approving nor arranging that in the pediments there should be either mutules or dentils, but plain cornices, this was because neither principals nor rafters are fixed to project on the front of gables, but are placed sloping down to the eaves. Thus what cannot happen in reality cannot (they thought) be correctly treated in the imitation. 6. For, by an exact fitness deduced from the real laws of nature, they adapted everything to the perfection of their work, and approved what they could show by argument, to follow the method of reality. And so they handed down the symmetry and proportions of each order as deter-

² Vitruvius holds that Symbolism should be consistent. It is because the later architects of the Renaissance used architectural forms without regard to their meaning that the purists denounced some lovely buildings.

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tas reliquerunt. Quorum ingressus persecutus de ionicis et corinthiis institutionibus supra dixi; nunc vero doricam rationem summamque eius speciem breviter exponam.

III

- 1 NONNULLI antiqui architecti negaverunt dorico genere aedes sacras oportere fieri, quod mendosae et disconvenientes in his symmetriae conficiebantur. Itaque negavit Arcesius,¹ item Pythius,² non minus Hermogenes. Nam is cum paratam habuisset marmoris copiam in doricae aedis perfectionem, commutavit ex eadem copia et eam ionicam Libero Patri fecit. Sed tamen non quod invenusta est species aut genus aut formae dignitas, sed quod inpedita est distributio et incommoda in opere triglyphorum
2 et lacunariorum distributione. Namque necesse est triglyphos constitui contra medios tetrantes columnarum, metopasque, quae inter triglyphos fient, aequae longas esse quam altas. Contraque in angulares columnas triglyphi in extremis partibus constituuntur et non contra medios tetrantes. Ita metopae quae proximae ad angulares triglyphos fiunt, non exeunt quadratae sed oblongiores triglyphi dimidia latitudine.³ At qui metopas aequales volunt facere, intercolumnia extrema contrahunt triglyphi dimidia latitudine.⁴ Hoc autem, sive in metoparum longitudini-

¹ Arcesius *Ro* : tarchesius *H*.

² pytheus *H*.

³ latitudine *Phil*.

⁴ latitudine *H*^c : altitudine *H*.

¹ Arcesius wrote upon the Corinthian order Book VII. pref. 12.

BOOK IV. c. II.—c. III.

mined from these beginnings. Following their footsteps I have spoken above of the Ionic and Corinthian orders, but now I shall briefly set forth the Doric manner and its general form.

CHAPTER III

ON THE DORIC ORDER

1. SOME ancient architects have said that temples should not be constructed in the Doric style, because faulty and unsuitable correspondence arose in them; for example Arcesius,¹ Pythius,² and especially Hermogenes. For the last named after preparing a supply of marble for a temple in the Doric style, changed over, using the same marble, and built an Ionic temple to Father Bacchus³ not because the form or style or dignity of the plan is displeasing, but because the distribution of the triglyphs and soffits is confused and inconvenient.

2. For it is necessary that the triglyphs should be placed over the middle quadrants of the columns, and that the metopes which are constructed between the triglyphs should be as broad as they are high. On the other hand, the triglyphs against the corner columns are placed at their furthest edge, and not against the middle of the columns. Thus the metopes which are made next to the corner triglyphs do not come out square but oblong by half the breadth of a triglyph. But those who wish to make the metopes equal contract the extreme intercolumniations by half the breadth of a triglyph. Whether the work

² Vitruvius' chief authorities were Pythius and Hermogenes.

³ At Teos, Book VII. pref. 12.

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bus sive intercolumniorum contractionibus efficietur, est mendosum. Quapropter antiqui vitare visi sunt in aedibus sacris doricae symmetriae rationem.

- 3 Nos autem exponimus, uti ordo postulat, quemadmodum a praeceptoribus accepimus, uti, si qui voluerit his rationibus adtendens ita ingredi, habeat proportionem explicatas, quibus emendatas et sine vitiis efficere possit aedium sacrarum dorico more perfectiones. Frons aedis doricae in loco, quo columnae constituuntur, dividatur, si tetrastylus erit, in partes xxvii, si hexastylus, xxxxi.¹ Ex his pars una erit modulus, qui Graece *embater* ² dicitur, cuius moduli constitutione ratiocinationibus efficiuntur
- 4 omnis operis distributiones. Crassitudo columnarum erit duorum modulorum, altitudo cum capitulo xiiii. Capituli crassitudo unius moduli, latitudo duorum et moduli sextae partis. Crassitudo capituli dividatur in partes tres, e quibus una plinthus cum cymatio fiat, altera echinus cum anulis, tertia hypotrachelion.³ Contrahatur columna ita, uti in tertio libro de ionicis est scriptum. Epistylus altitudo unius moduli cum taenia et guttis; taenia moduli septima; guttarum longitudo sub taenia contra triglyphos alta cum regula parte sexta moduli praependeat. Item epistylus⁴ latitudo ima respondeat hypotrachelio summae columnae. Supra epistylium conlocandi sunt triglyphi cum suis metopis, alti unius <et>⁵

¹ xxvii . . . xxxxi *Phil*: xxviii . . . xxxii *H*.

² *cf.* I. ii. 4: *embates H*.

³ hypotrachelion *Phil*: ypotrachelio *H*.

⁴ epistylis *H*. ⁵ *add. Joc.*

¹ Sometimes the diameter equals one module, III. iii. 7.

BOOK IV. c. III.

proceeds by lengthening the metopes or contracting the intercolumniations, it is faulty. Hence the ancients, as it seems, avoided the Doric order in temples.

3. Now we, following the arrangement demanded in accordance with the instruction of our masters, proceed in such a way that, if the reader will conform to our methods, he may find those proportions set forth by which he can carry out temples in the Doric style faultless and without blemish. The front of a Doric temple is to be divided along the line where columns are set, into 27 parts if it is tetrastyle, into 42 parts if it is hexastyle. Of these one part will be the module (which in Greek is called *embater*) and when this is determined, the distribution of all the work is produced by multiples of it. 4. The diameter of the columns will be two modules,¹ the height including the capital 14, the height of the capital is one module, the width two modules and a sixth. The height of the capital is to be divided into three parts, of which one is to be the abacus with the cymatium; the second the echinus with fillets; the third the necking. The column is to be diminished as directed for the Ionic order in the third book. The height of the architrave is to be one module including the taenia and guttae; the taenia is to be the seventh part of a module; the length of the guttae under the taenia corresponds to the triglyphs, and is to hang down, including the fillet, the sixth part of a module. The breadth also of the architrave at the soffit is to correspond to the necking of the column at the top. Above the architrave are to be placed the triglyphs with the metopes; the triglyphs being a module

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dimidiati moduli, lati in fronte unius moduli, ita divisi, ut in angularibus columnis et in mediis contra tetrantes medios sint conlocati, et intercolumniis reliquis bini,¹ in mediis pronao et postico terni. Ita relaxatis mediis intervallis sine inpeditionibus aditus
5 accedentibus erit ad deorum simulacra. Triglyphorum latitudo dividatur in partes sex, ex quibus quinque partibus in medio, duae dimidiae dextra ac sinistra designentur regula. Una in medio deformetur femur, quod Graece *meros* ² dicitur; secundum eam canaliculi ad normae cacumen inprimantur; ex ordine eorum ³ dextra ac sinistra altera femina constituentur; in extremis partibus semicanaliculi intervertantur. Triglyphis ita conlocatis, metopae quae sunt inter triglyphos,⁴ aequae altae sint quam longae; item in extremis angulis semimetopia ⁵ sint inpressa dimidia moduli latitudine. Ita enim erit, ut omnia vitia et metoparum et intercolumniorum et lacunarium, quod aequales divisiones factae erunt,
6 emendentur. Triglyphi capitula sexta parte moduli sunt faciunda. Supra triglyphorum capitula corona est conlocanda in proiectura dimidia et sextae partis ⁶ habens cymatium doricum in imo, alterum in summo. Item cum cymatiis corona crassa ex dimidia moduli. Dividendae autem sunt in corona ⁷ ima ad perpendicularum triglyphorum et medias metopas viarum derectiones et guttarum distributiones,

¹ bini *Joc* : binis *H*.

² *μηρός* *Joc* : eros *H*.

³ eorum *Joc* : earum *H*.

⁴ inter glyphos *H*.

⁵ semimetopia *Joc* : semi memphia *H*.

⁶ sextae partis *rec* : sextae parte *H* *G*.

⁷ corona : columna *H*.

¹ The meaning of *via* is uncertain; it probably denotes the spaces between the mutules.

BOOK IV. c. III.

and a half high and one module wide in front, and so distributed that in the columns both at the corners and in the middle, they are placed over the centres. In the middle intercolumniations of the front and back there are to be three, in the other intercolumniations there are to be two triglyphs. The middle intercolumniations are to be thus widened so that for those who are approaching the statues of the gods there may be an uninterrupted approach. 5. The width of the triglyphs is to be divided into six parts, of which five parts are to be in the middle, and two halves right and left are to be marked by the length of the fillet. The part in the middle is to be shaped flat as the *thigh* (which in Greek is called *mēros*). Parallel channels are to be sunk with sides meeting in a right angle. To the right and left of them, in order, other flat surfaces or thighs are to be put. At the furthest edges, half channels are to be put. After placing the triglyphs, the metopes which separate them, are to be made as high as they are long. Further, at the extreme corners, half metopes are to be made half a module wide. Hence the divisions will be made uniform and all the faults, both of metopes and intercolumniations and soffits, will be removed. 6. The capitals of the triglyphs are to be made of the sixth part of a module. Above the capitals of the triglyphs, the cornice is to be placed projecting two thirds of a module, with a Doric cymatium below and another at the top. Further, with the cymatia, the cornice will be half a module high. Now in the lowest part of the cornice, above the triglyphs and the middle of the metopes, the lines of the *viae*¹ and the rows of the guttae are to

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ita uti guttae sex in longitudinem, tres in latitudinem pateant. Reliqua spatia, quod latiores sint metopae quam triglyphi, pura relinquantur aut numina¹ scalpantur, ad ipsumque mentum coronae incidatur linea quae scotia dicitur. Reliqua omnia, tympana, simae,² coronae, quemadmodum supra scriptum est in ionicis, ita perficiantur.

- 7 Haec ratio in operibus diastylis³ erit constituta. Si vero systylon et monotriglyphon opus erit faciendum, frons aedis, si tetrastilo erit, dividatur in partes XVIII s,⁴ si hexastilos erit, dividatur in partes XXVIII s. Ex his pars una erit modulus, ad quem,
8 uti supra scriptum est, dividantur. Ita supra singula epistylia et metopae⁵ et triglyphi bini erunt conlocandi; in angularibus hoc amplius, quantum dimidiatum est spatium hemitriglyphi, id accedit. In mediano⁶ contra fastigium trium triglyphorum et trium metoparum spatium distabit, quod latius medium intercolumnium accedentibus ad aedem habeat laxamentum et adversus simulacra deorum aspectus dignitatem.

- 9 Columnas autem striari xx striis oportet. Quae si planae erunt, angulos habeant xx designatos. Sin autem excavabuntur, sic est forma facienda, ita uti quam magnum est intervallum striae, tam magnis striaturae paribus lateribus quadratum describatur;

¹ numina *Gr*: flumina *H* cf. numinum simulacra Tac. A. I 73, effigies numinum, A. I 10; III 71.

² simae *Joc*: et imae *H*.

³ diastylis *ed*: -liis *H*.

⁴ XVIII s . . . XXVIII s *Barbarus*: XVIII . . . XXVIII *H*.

⁵ metopae *Joc*: metopha *H*.

⁶ [habens—perpendicularum] *H* ex 6 supra, moduli om. *H*.

BOOK IV. c. III.

be divided so that there are six guttae in the length and three in the breadth. The remaining spaces, because the metopes are broader than triglyphs, are to be left plain, or divine images are to be carved; and at the very edge of the cornice a line is to be cut in which is called the scotia. All the rest—namely the field of the pediment, the cymas, the cornices—are to be finished as prescribed above for Ionic buildings.

7. Such is the method that will be appointed for diastyle works. But if the work is to be systyle and with single triglyphs, the front of a tetrastyle temple is to be divided into nineteen and a half parts; of a hexastyle temple into twenty nine and a half parts. Of these one part will be the module according to which they are to be divided, as written above.¹

8. Thus above the single architraves, two metopes and two triglyphs are to be placed. At the angles² in addition, as much as is half a triglyph is put. Against the middle of the pediment, a space will intervene of three triglyphs and three metopes, in order that the middle intercolumniation, being broader, may give room to persons approaching the temple, and furnish a dignified appearance as one goes to meet the Image of the God.

9. The columns ought to be fluted with 20 flutes.³ If the flutes are flat, the columns must have 20 vertical edges marked. But if the flutes are hollow, we must fix their form in this way: draw a square with equal sides as great as is the width of the fluting.

¹ The module for Doric buildings is half a diameter, § 3.

² See Plate E.

³ The old, and present, Parthenon have 20 flutes on the shafts.

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in medio autem quadrato circini centrum ¹ conlocetur et agatur linea rotundationis, quae quadrationis angulos tangat, et quantum erit curvaturae inter rotundationem et quadratam descriptionem, tantum ad formam excaventur. Ita dorica columna sui
10 generis striaturae habebit perfectionem. De adiectione eius, qua media adaugetur, uti in tertio volumine de ionicis est perscripta, ita et in his transferatur.

Quoniam exterior species symmetriarum et corinthiorum et doricorum et ionicorum est perscripta, necesse est etiam interiores cellarum pronaique distributiones explicare.

IV

- 1 DISTRIBUITUR autem longitudo aedis, uti latitudo sit longitudinis dimidia² partis, ipsaque cella parte quarta longior sit, quam est latitudo, cum pariete qui paries valvarum habuerit ² conlocationem. Reliquae tres partes pronai ad antas parietum procurrant, quae antae columnarum crassitudinem habere debent. Et si aedes erit latitudine maior quam pedes xx, duae columnae inter duas antas interponantur, quae disiungant pteromatos ³ et pronai spatium. Item intercolumnia tria quae erunt inter antas ⁴ et columnas, pluteis marmoreis sive ex in-

¹ centrum *SE*: centum *H*.

² habuerit *G*: hab&erit *H*.

³ pteromotos *H*.

⁴ inter interantas *H*.

BOOK IV. C. III.—C. IV.

Now in the middle of the square the centre of a circle is to be placed, and let a circle be described which touches the angles of the square; and the curve which comes between the circumference and the side of the square, will give the hollow of the flutes. Thus the Doric column will have the fluting proper to its order. 10. Concerning the entasis of the column by which it is increased in the middle, the method prescribed in the third book for the Ionic order is to be imitated in the case of the Doric order.

Inasmuch as the external appearance of the symmetries of the Corinthian and Doric and Ionic orders has been described, we must proceed to explain the interior distribution of the apartments of the temple, and also of the approach to the temple.

CHAPTER IV

ON THE INTERIOR OF THE TEMPLE, AND THE PRONAOS

1. THE length of the temple is so arranged that the breadth is half the length. The cella itself is to be a fourth part longer than its breadth, including the wall which contains the doors. The remaining three parts, that is, the portico, are to run forward to the antae of the walls. The antae ought to have the thickness of the columns. If the temple be more than 20 feet in breadth, between the two antae two columns are to be placed and these columns are to separate the portico and the *pteroia*.¹ Between the three intercolumniations, which will come between the antae and the columns, let there

¹ Book III. iii. 9; the colonnade which surrounds the temple.

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testino opere factis intercludantur, ita uti fores
 2 habeant, per quas itinera pronao fiant. Item si
 maior erit latitudo quam pedes XL, columnae contra
 regiones¹ columnarum, quae inter antas sunt,
 introrsus conlocentur. Et hae altitudinem habeant
 aequae quam quae sunt in fronte, crassitudines autem
 earum extenuentur his rationibus, uti, si octava
 parte erunt quae sunt in fronte, hae fiant x parte,
 sin autem viii aut decima, pro rata parte.² In
 concluso enim aere si quae extenuatae erunt, non
 discernentur. Sin autem videbuntur graciliores,
 cum exterioribus fuerint striae <xx aut>³ xxiii, in
 his faciendae erunt xxviii aut xxxii. Ita quod detra-
 hitur de corpore scapi, striarum numero adiecto
 adaugebitur ratione, quo minus videtur, et ita
 exaequabitur dispari ratione columnarum crassitudo.
 3 Hoc autem efficit ea ratio, quod oculus plura et
 crebriora signa⁴ tangendo maiore visus circuitione
 pervagatur. Namque si duae columnae aequae
 crassae lineis circummetientur, e quibus una sit non
 striata, altera striata, et circa strigium cava et
 angulos striarum linea corpora tangat, tametsi colum-
 nae aequae crassae fuerint, lineae, quae circumdatae
 erunt, <non erunt>⁵ aequales, quod striarum et stri-
 gium circuitus maiorem efficit lineae longitudinem.
 Sin autem hoc ita videbitur, non est alienum in
 angustis locis et in concluso spatio graciliores colum-
 narum symmetrias in opere constituere, cum habe-
 4 amus adiutricem striatarum⁶ temperaturam. Ipsius

¹ regiones *rec*: religiones *H.* ² parte *Ro*: partes *H.*

³ *add. Meister.*

⁴ signa *rec*: signat *H.*

⁵ *add. Joc.*

⁶ striarum *ed*: striatarum *H.*

¹ Varro *R.R.* III. i. 10; Plin. *N.H.* XVI. 225.

BOOK IV. c. iv.

be a fence of marble or of fine joinery¹ with gates² by which the portico may be entered. 2. Also if the breadth be more than 40 feet, columns are to be placed towards the inner part, in a direct line with those which are between the pilasters. These other columns are to have the same height as those in front, but their diameters are to be lessened in the following manner: if the diameter of the front columns is one eighth of their height, the side diameters are to be one tenth; if the front diameter is one ninth or one tenth, then proportionately. For being diminished in an enclosed space, they will not be remarked. But if they should seem too slender they may have 28 or 32 flutes against the outside 20 or 24. Thus what is taken from the diameter of the shaft will be added by the extra number of the flutes, so as not be observed. In this way the varying diameter of the columns will be balanced. 3. This effect is produced for the following reason. The eye thus touches a greater number of points,³ and ranges over a larger circumference of vision. For if two columns of equal diameter, of which one is fluted and the other is not, have a line measured round them and one line touches the shafts of the columns round the flutes and their fillets, although the columns are of equal diameter, the bounding lines will not be equal because the circuit of the fillets and the flutes produces a greater length of line. Now if this shall seem to be the case, it is not inappropriate, in narrow places and a confined space, to use in building more slender proportions for the columns, since we have the adjustment of the fluting to help us. 4. The thickness of the walls

² Not doors.

³ Perspective again.

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autem cellae parietum crassitudinem pro rata parte magnitudinis¹ fieri oportet, dum antae eorum crassitudinibus columnarum sint aequales. Et si extracti futuri sunt, quam minutissimis caementis struantur, sin autem quadrato saxo aut marmore, maxime modicis paribusque videtur esse faciundum, quod media coagmenta medii lapides continentes firmiorem facient omnis operis perfectionem. Item circum coagmenta et cubilia eminentes expressiones *graphicoteran* efficient in aspectu delectationem.

V

- 1 REGIONES autem, quas debent spectare aedes sacrae deorum immortalium, sic erunt constituendae, uti, si nulla ratio inpedierit liberaque fuerit potestas, aedis signumque quod erit in cella² conlocatum, spectet ad vespertinam caeli regionem, uti, qui adierint ad aram immolantes³ aut sacrificia facientes, spectent ad partem caeli orientis et simulacrum, quod erit in aede, et ita vota suscipientes contueantur aedem⁴ et orientem caelum ipsaque simulacra videantur exorientia contueri supplicantes et sacrificantes, quod aras omnes deorum necesse esse
- 2 videatur ad orientem spectare. Sin autem loci natura interpellaverit, tunc convertendae sunt earum regionum constitutiones, uti quam plurima pars moenium e templis eorum conspiciatur. Item si secundum flumina aedis sacra fiet, ita uti Aegypto

¹ magnitudines *H.*

² cella *rec* : cellae *H.*

³ immolantis *H.*

⁴ eadem *H* : aedem *G.*

¹ Caelus is masc, and a god. Cic. *N.D.* III. 55 ff.

BOOK IV. c. iv.—c. v.

of the cella itself ought to be proportionate to its dimensions, provided that the antae (front pilasters) are equal to the diameter of the columns, and if the walls are continued into the pilasters, they are to be of very small stones. But if the antae are built of square stone or marble, the pieces should be of moderate and equal size. For the middle of the stones in the course above will bind together the joints below them and will strengthen the execution of the whole work. Further, the raised pointing about the upright and bed joints will produce a more picturesque effect in the general view.

CHAPTER V

ON THE ASPECT OF A TEMPLE

1. THE aspects which the sacred temples of the immortal gods ought to regard are so to be appointed (if no reason hinders, and the opportunity is presented) that the temple and the Statue which is in the shrine look towards the western quarter of the sky, so that those who come to the altar to sacrifice or make offerings may look towards the eastern Heaven¹ and the image in the temple. In like fashion persons undertaking vows may look upon the temple and the eastern Heaven. And the very images may seem to rise up and gaze upon those who make vows and sacrifices. For all the altars of the gods should look to the east. 2. But if the nature of the site interferes, the aspect of the temple must be so altered that the greatest possible part within the walls of the city may be visible from the temples of the gods. Also if a sacred temple is raised along

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circa Nilum, ad fluminis ripas videantur¹ spectare debere. Similiter si circum vias publicas erunt aedificia deorum, ita constituentur, uti praetereuntes possint respicere et in conspectu salutationes facere.

VI

- 1 OSTIORUM autem et eorum antepagmentorum in aedibus hae sunt rationes, uti primum constituentur, quo genere sint futurae. Genera sunt enim thyromaton haec: doricum, ionicum, atticurges.

Horum symmetriae conspiciuntur his rationibus, uti corona summa, quae supra antepagmentum superius inponetur, aequae librata sit capitulis summis columnarum quae in pronao fuerint. Lumen autem hypaethri constituatur sic, uti quae altitudo aedis a pavimento ad lacunaria fuerit, dividatur in partes tres semis et ex eis duae partes² <semis> lumini³ valvarum altitudine constituentur. Haec autem dividatur in partes xii et ex eis quinque et dimidia latitudo⁴ luminis fiat in imo. Et in summo contrahatur, si erit lumen ab imo ad sedecim pedis, antepagmenti iii parte; xvi pedum ad xxv, superior pars luminis contrahatur antepagmenti parte iiii; si ab⁵ pedibus xxv ad xxx, summa pars contrahatur antepagmenti parte viii. Reliqua, quo altiora erunt,
2 ad perpendicularum videntur oportere conlocari. Ipsa

¹ videatur *rec*: videantur *H*.

² partis *H* *add. Rode*.

³ lumini *Joc*: lumine *H*.

⁴ latitudo *H*° altitudo *a. c. H*.

⁵ ad pedibus *H* et *a. ras. S*.

¹ These were usually of fine joiners' work.

BOOK IV. c. v.—c. vi.

the riverside, as by the Nile in Egypt, it ought to seem to regard the banks of the river. Likewise if the edifices of the gods are about the public thoroughfares, they are to be so arranged that the passers-by can look aside, and make their reverence in full view.

CHAPTER VI

ON THE DOORS OF TEMPLES

1. THE following are the rules for doorways to temples and their architraves. First we must determine of what style they are to be. For the styles of doorways are these : Doric, Ionic, Attic.

Of these (as concerns the Doric) the proportions are found to be of the following character. The top of the cornice which is put above the upper architrave, is made level with the tops of the capitals of the columns which are in the pronaos. The opening of the doorway is to be so determined that the height of the temple from the pavement to the panels of the ceiling is to be divided into $3\frac{1}{2}$ parts, and of these $2\frac{1}{2}$ in height are to be fixed for the opening of the folding doors.¹ Let this in turn be divided into 12 parts and of these let $5\frac{1}{2}$ be the breadth of the opening at the bottom. Let it be diminished at the top a third of the width of the architrave, if the opening be not more than 16 feet high; if from 16 to 25 feet, let the upper part of the opening be contracted $\frac{1}{4}$ of the architrave; from 25 to 30 feet, $\frac{1}{8}$ of the architraves. Higher openings should have perpendicular sides. 2. The architraves² themselves

¹ This term is used in modern building to denote the mouldings at the side of the door as well as at the top.

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autem antepagmenta contrahantur in summo suae crassitudinis XIII parte. Supercilii crassitudo, quanta antepagmentorum in summa parte erit crassitudo. Cymatium faciundum est antepagmenti parte sexta; proiectura autem, quanta est eius crassitudo. Sculptum est cymatium lesbium cum astragalo. Supra cymatium quod erit in supercilio, conlocandum est hyperthyrum crassitudine supercilii, et in eo scalpendum est cymatium doricum, astragalum lesbium sima sculptura. Corona plana cum cymatio; proiectura autem eius erit quanta altitudo. Supercilii, quod supra antepagmenta inponitur, dextra atque sinistra proiecturae sic sunt faciundae, uti crepidines excurrant et in ungue ipso cymatio coniungantur.

- 3 Sin autem ionico genere futura erunt, lumen altum ad eundem modum quemadmodum in doricis fieri videtur. Latitudo constituatur, ut altitudo dividatur in partes duas et dimidiam, eiusque partis unius ima luminis¹ fiat latitudo. Contracturae ita uti in doricis. Crassitudo antepagmentorum <ex>² altitudine luminis in fronte XIII parte, cymatium huius crassitudinis sexta. Reliqua pars praeter cymatium dividitur in partes XII. Harum³ trium prima corsa fiat cum astragalo, secunda quattuor, tertia quinque, et eae⁴ aequae corsae cum astragalis circumcurrant.
- 4 Hyperthyra⁵ autem ad eundem modum componantur quemadmodum in doricis pro ratis⁶ pedibus. Ancones, sive parotides⁷ vocantur, exalpta dextra ac sinistra praependeant ad imi supercilii libra-

¹ ima luminis *G* simalum in his *H*. ² ex *add. Kr*.

³ harum *Joc*: horum *x*. ⁴ et eae *Ro*: ex ea *H*.

⁵ hyperthyra *Joc*: hypetra *H*. ⁶ pro ratis *Ro*: protis *H*.

⁷ parotides *Schn*: protides *H*.

¹ Lit. "ear-pieces."

BOOK IV. c. vi.

are to be contracted $1/14$ part of their width at the top. The height of the lintel is to be the same as that of the architraves at the top. The cymatium (ogee) should be made one sixth of the architrave, projecting the amount of its thickness. It is to be carved in the Lesbian form with an astragal. Above the cymatium of the lintel, the frieze is to be placed as deep as the lintel; and on it is to be carved a Doric cymatium and a Lesbian astragal in low relief. Over this the cornice is to be carved without ornament and with a cymatium; its projection is to be as much as its height. To the right and left of the lintel, which is placed above the jambs, projections are to be made so that the bases run out, and are exactly joined to the cymatium with a mitre.

3. If the doorways are to be of the Ionic style, the opening must be of a height determined as in the Doric style. Let the breadth be determined, so that the height is divided into $2\frac{1}{2}$ parts, and let the breadth of the opening at the bottom be one part. The contractions are to be as in the Doric. The width of the architrave is to be $1/14$ of the height of the opening in front; the cymatium is to be $1/6$ of the width of the architrave. The remainder, excluding the cymatium, is divided into 12 parts. The first fascia with the astragal is to be three parts of these; the second, of four parts; the third, of five parts. The fasciae with the astragal are to run evenly round the architrave. 4. The tops of the doorways are as in the Doric style, with the proportionate dimensions. Brackets (or, as they are called, *parotides*¹) are to be carved right and left and to hang over to the level of the bottom of the

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mentum, praeter folium. Eae habeant in fronte crassitudinem <ex> antepagmenti¹ tribus partibus, in imo quarta parte graciliore quam superiora.

Fores ita compingantur, uti scapi cardinales sint ex latitudine luminis totius xii parte. Inter duos scapos tympana ex xii partibus habeant ternas partes. 5 Inpagibus² distributiones ita fient, uti divisis altitudinibus in partes v duae superiori, tres inferiori designentur. Super medium medii inpages conlocentur, ex reliquis alii in summo, alii in imo compingantur. Altitudo inpagis fiat tympani tertia parte, cymatium sexta parte inpagis. Scaporum latitudines inpagis dimidia parte, item replum de inpage dimidia et sexta parte. Scapi, qui sunt secundum antepagmentum,³ dimidium inpagis constituentur. Sin autem valvatae erunt, altitudines ita manebunt, in latitudinem adiciatur amplius foris latitudo. Si quadriforis futura est, altitudo adiciatur.

6 Atticurge⁴ autem isdem rationibus perficiuntur, quibus dorica. Praeterea corsae⁵ sub cymatiis in antepagmentis circumdantur, quae ita distribui debent, uti antepagmenti⁶ praeter cymatium ex partibus vii habeant duas partes. Ipsaeque non fiunt clathrata⁷ neque bifora sed valvata, et aperturas habent in exteriores partes.

Quas rationes aedium sacrarum in formationibus oporteat fieri <doricis>,⁸ ionicis corinthisque operibus,

¹ antepagmenti *Joc* : -tis *H*.

² inpagibus *ed* : inpaginibus *II*.

³ secundum antepagmentum (*Baldus*) : ante secundum pagmentum *H*.

⁴ atticurge *Nohl* : adtigurges *H*.

⁵ gorsae *H*.

⁶ antepagmenti *Ro* : ante pagmenta *H*.

⁷ clathrata *ed. Ven* : caelostrata *H*.

⁸ *add. ed. Fl.*

BOOK IV. c. vi.

lintel, with the leaf below that level. Their width on the face is two thirds of the architrave, being one fourth more slender at the bottom than the upper parts.

The doors are to be so put together that the hinge stiles¹ are $\frac{1}{12}$ of the breadth of the whole opening. The panels between the two stiles are to have 3 parts out of 12 in width. 5. For the rails, the distribution shall be such that, taking the height to be of 5 parts, two are assigned to the upper portion, 3 to the lower portion. Let the middle rails be placed above the centre; of the others one set are at the top of the doors, the others at the bottom. The width of the rail is to be one third of the panel; the cymatium $\frac{1}{6}$ of the rail. The breadth of the inner stiles is to be half the rail, and the cover-moulding $\frac{2}{3}$ of the rail. The stiles against the architrave are made one half the rail. If the doors are folding, the heights remain the same; but let the breadth of the opening be increased. If the doors are fourfold, let the height be increased.

6. Attic doors are made of the same proportions as the Doric, the fasciae, however, are carried round under the cymatia in the architraves, and ought to be so arranged that of the architrave, exclusive of the cymatium, they have 2 parts out of 7. They are to be without lattice-work and are not to have hinges folding inwards, but to fold outwards on sockets.²

As far as I could attain, I have set forth, as on approved lines, the methods which ought to be

¹ The uprights of the door, containing the panels, with "rails" as the cross-pieces.

² Juv. IV. 63, *facili patuerunt cardine valvae*.

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quoad potui attingere, veluti legitimis moribus exposui. Nunc de tuscanicis dispositionibus, quemadmodum institui oporteat, dicam.

VII

- 1 Locus, in quo aedis constituetur, cum habuerit in longitudine sex partes, una adempta reliquum quod erit, latitudini detur. Longitudo autem dividatur bipertito, et quae pars erit interior, cellarum spatiis designetur, quae erit proxima fronti, columnarum dispositione relinquatur. Item latitudo dividatur in 2 partes x. Ex his ternae partes dextra ac sinistra cellis minoribus, sive ibi alae¹ futurae sunt, dentur; reliquae quattuor mediae aedi attribuantur. Spatium, quod erit ante cellas in pronao, ita columnis designetur, ut angulares contra antas, parietum extremorum regione, conlocentur; duae mediae e regione parietum, qui inter antas et mediam aedem fuerint, ita distribuuntur; et inter antas et columnas priores per medium isdem regionibus alterae disponantur.² Eaeque sint ima³ crassitudine altitudinis parte vii; altitudo tertia parte latitudinis templi; summaque columna quarta parte crassitudinis imae⁴ contrahatur.
- 3 Spirae earum altae⁵ dimidia parte crassitudinis fiant. Habeant spirae earum plinthum ad circinum, altam suae crassitudinis dimidia parte, torum insuper cum

¹ alae *Joc* : aliae *H*.

² alterae disponantur *Joc* : altera aedis ponatur *H*.

³ eaeque sint ima *Joc* : aequae intima *H*.

⁴ imae *Joc* : ima *H*. ⁵ altae *Joc* : alia *H*.

BOOK IV. c. VI.-C. VII.

followed in planning temples of the Doric, Ionic and Corinthian orders. Now I will speak of the Tuscan style and the method to be employed therein.

CHAPTER VII

ON THE TUSCAN STYLE

1. LET the site on which the temple is to be built be six parts in length; five parts are to be assigned to the breadth. Now the length is to be divided in two. The interior half is to be marked out by the dimensions of the sanctuary; the part on the front is to be left for the portico with its columns. 2. Further, let the width be divided into 10 parts. Of these let three parts each on the right and left be given to the lesser sanctuaries, or alternately to the wings; the remaining four parts are to be given to the central shrine. Let the space which is before the sanctuaries in the forecourt be planned for the columns, in such a way that the corner columns are put opposite the pilasters, in line with the ends of the walls. The two middle columns are to be in line with the walls which are between the wings and the middle shrine. Between the pilasters and the columns in front, additional columns are to be put half way in line with them. At the bottom these are to have a diameter $\frac{1}{7}$ of the height. (The height is to be one third of the width of the temple.) The top of the column is to be diminished $\frac{1}{4}$ of the diameter at the bottom. 3. The bases are to be made half a diameter high. Let the bases have their plinths circular and half the height of the

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apophysi¹ crassum quantum plinthus. Capituli altitudo dimidia crassitudinis. Abaci latitudo quanta ima crassitudo columnae. Capitulique crassitudo dividatur in partes tres, e quibus una plintho, quae est in abaco, detur, altera echino, tertia hypotrachelio
4 cum apophysi. Supra columnas trabes compactiles inponantur ut altitudinis modulis is, qua magnitudine operis postulabuntur.² Eaeque trabes compactiles ponantur ut eam habeant crassitudinem, quanta summae columnae erit hypotrachelium, et ita sint compactae subscudibus et securiclis, ut compactura duorum digitorum habeant laxationem. Cum enim inter se tangunt et non spiramentum et perflatum venti recipiunt, concalefaciuntur et celeriter putrescunt.
5 supra trabes et supra parietes traiecturae mutulorum parte III altitudinis columnae proiciantur; item in eorum frontibus³ antepagmenta figantur.⁴ Supraque id tympanum fastigii structura seu de materia conlocetur. Supraque eum fastigium, columnen, cantherii, templa ita sunt conlocanda, ut stillicidium tecti absoluti tertiaro respondeat.

VIII

1 FIUNT autem aedes rutundae, e quibus aliae monopteroe sine cella columnatae constituuntur, aliae peripteroe dicuntur. Quae sine cella fiunt, tribunal habent et ascensum ex sua diametro tertiae partis.

¹ apophysi *rec* : apopysi *H*.

² postulabuntur *Jac* : postulabantur *H*.

³ frontibus *G* : proutibus *H*.

⁴ ficantur *H*.

¹ Round moulding.

² The curving away of the shaft against the base.

³ Necking. ⁴ *Tribunal*.

BOOK IV. c. VII.—C. VIII.

base, with a torus¹ and *apophysis*² as deep as the plinth. The height of the capital is to be half a diameter. The width of the abacus is as great as the diameter of the column at the base. The height of the capital is to be divided into three parts, of which one is to be given to the plinth or abacus, one to the echinus or ovolo, the third to the hypotrachelium³ with the apophysis. 4. Above the columns, beams are to be placed bolted together, of such proportionate depth as shall be demanded by the magnitude of the work. And these coupled beams are to have a thickness equal to the hypotrachelium at the top of the column, and they are to be so coupled with dowels and mortices that the coupling allows an interval of two inches between the joists. For when they touch one another and do not admit a breathing space and passage of air, they are heated and quickly decay. 5. Above the beams and walls the mutules are to project $\frac{1}{4}$ of the height of the column. On the front of these, casings (*antepagmenta*) are to be fixed and above them the tympanum of the gable either of stone or wood. Above this the ridge-piece, rafters, and purlins, are to be so placed that the pitch of the roof is one in three.

CHAPTER VIII

ON CIRCULAR TEMPLES

1. CIRCULAR temples are also built, of which some are monopteral built with columns but not enclosing a cella; others are peripteral. Those which are without a cell have a raised floor⁴ and a flight of steps one third of the diameter in height. Above

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Insuper stylobata columnae constituuntur tam altae, quanta ab extremis parietibus est diametros stylobatarum, crassae altitudinis suae cum capitulis et spiris decumae partis. Epistylum altum columnae crassitudinis dimidia parte. Zophorum et reliqua, quae insuper inponuntur, ita uti in III¹ volumine de symmetriis scripsi.

- 2 Sin autem peripteros ea aedes constituetur, duo gradus et stylobata ab imo constituentur. Deinde cellae paries conlocetur cum recessu eius a stylobata circa partem latitudinis quintam, medioque valvarum locus ad aditus relinquatur²; eaque cella tantam habeat diametrum praeter parietes et circumitionem, quantam altitudinem columna. Supra stylobata columnae circum cellam isdem symmetriisque
3 disponantur. In medio tecti ratio ita habeatur, uti, quanta diametros totius operis erit futura, dimidia altitudo fiat tholi praeter florem; flos autem tantam habet magnitudinem, quantam habuerit columnae capitulum, praeter pyramidem. Reliqua, uti supra scripta sunt ea, proportionibus atque symmetriis facienda videntur.
- 4 Item generibus aliis constituuntur aedes ex isdem symmetriis ordinatae et alio genere dispositiones habentes, uti est Castoris in circo Flaminio et inter duos lucos Veiovis, item argutius Nemori Dianae

¹ tertio *Joc* : quarto *H*.

² relinquatur *S*^c : relinquantur *H*.

¹ Cf. terminal on mausoleum of Hadrian (Winckelmann *History*, II. iv. Ib.) now replaced by angel.

² Lanciani *RE* 443. This was in the Doric order, apparently. Platner 102.

³ This temple was between the Capitol and the Arx. Ovid *Fasti* III. 437. Burn, *Rome* 196. Platner 548.

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the pedestal (stylobate) the columns are put of such a height as is the diameter of the pedestals from side to side; the diameter is to be $\frac{1}{10}$ of the height including the capitals and bases. The architrave is to be half a diameter high. The frieze and the other members which are placed above are to follow the proportions given in the third book.

2. But if the temple is peripteral, two steps and the stylobate are to be built from the foundation; then the wall of the cella is to be built set back from the edge of the stylobate about $\frac{1}{5}$ of the width. In the middle is to be left an opening with folding-doors for the approach. The cella within the walls and colonnade, is to have a diameter equal to the height of the column. On the stylobate, let columns be disposed round the cella and of the same proportions. 3. In the middle let the proportions of the roof be such that the height of the dome, apart from the terminal, is half the diameter of the whole work. Let the terminal have the magnitude of the capital of the column in addition to the pyramid (on which the flower¹ rests). The other parts are to be constructed of the proportions and symmetries as is above described.

4. Further, temples of other orders are laid out and built with the same symmetries, yet having the arrangements of another order than the Tuscan: such as the temple of Castor² in the Circus Flaminius, of Veiovis³ between the Two Groves, and with more subtle proportions the temple of Diana Nemorensis⁴

⁴ Of this temple, considerable remains were excavated in 1885 by Lord Savile: *Catalogue of Nemi Collection*, Nottingham.

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- columnis adiectis dextra ac sinistra ad umeros pronai. Hoc autem genere primo facta est, uti est Castoris in circo, Athenis in arce et in Attica Sunio Palladis Minervae. Earum non aliae sed eadem¹ sunt proportiones. Cellae enim longitudinibus duplices sunt ad latitudines² uti reliquae; ex is omnia³ quae solent esse in frontibus, ad latera sunt translata.
- 5 Nonnulli etiam de tuscanicis generibus sumentes columnarum dispositiones transferunt in corinthiorum et ionicorum operum ordinationes, et quibus⁴ in locis in pronao procurunt antae, in isdem e regione cellae parietum columnas binas conlocantes efficiunt tuscanicorum et graecorum operum communem ratiocinationem.
- 6 Alii vero removeantes parietes aedis⁵ et adplicantes ad intercolumnia pteromatos,⁶ spatii sublatis efficiunt amplum laxamentum cellae; reliqua autem proportionibus et symmetriis isdem conservantes aliud genus figurae nominisque videtur pseudoperipterum procreavisse. Haec autem genera propter usum sacrificiorum convertuntur. Non enim omnibus diis isdem rationibus aedes sunt faciundae, quod alius alia varietate sacrorum religionum habet effectus.
- 7 Omnes aedium sacrarum ratiocinationes, uti mihi traditae sunt, exposui ordinesque et symmetrias eorum partitionibus distinxi, et quorum dispares sunt figurae et quibus discriminibus inter se sunt dispa-

¹ eadem *S*: eadem *H G*.

² latitudines *Joc*: altitudines *H*.

³ omnia *Turnebus*: reliqua exisone *H*.

⁴ et quibus *Schn*: equibus *H*.

⁵ aedis *G^o*: aedes *H*.

⁶ pteromatos *ed. Fl*: pleromatos *H*.

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with columns added right and left on the sides of the pronaos. The first temples built in the manner of that of Castor in the Circus, were those of Pallas (Minerva) in the Acropolis¹ at Athens, and at Sunium in Attica, of the same and not different proportions. For like the others, the cells are double in length compared to the breadth. In these temples also, all the features which are customary on the front are transferred to the flanks. 5. For some taking the arrangements of the columns from the Tuscan style, transfer them to the design of Corinthian and Ionic buildings. And where the pilasters run forward in the forecourt, they place *two* columns in line with the walls of the cella and produce a system common to Tuscan and Greek forms of building. 6. Others again, removing the walls of the shrine and putting them in the intercolumniations of the colonnade,² produce a large extension of the cella by the space thus gained; keeping the other parts, however, of the same proportions and symmetries, they seem to have created another kind of plan and of name, the pseudoperipteral. The styles of building vary to suit the needs of sacrifice. For temples are not to be built to all the gods in the same styles. For the several gods by the variety of their worship give rise to different religious effects.

7. I have set forth all the plans of temples as they have been taught me, and have distinguished in detail their orders and symmetries, the difference of their forms and the details by which they are dis-

¹ The Parthenon.

² As at the Maison Carrée at Nîmes. This really is the starting point of the Palladian style.

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tae, quoad potui significare scriptis, exposui. Nunc de areis deorum immortalium,¹ uti aptam constitutionem habeant ad sacrificiorum rationem, dicam.

IX

ARAE spectent ad orientem et semper inferiores sint conlocatae quam simulacra quae fuerint in aede, uti suspicientes divinitatem, qui supplicant, et sacrificant, disparibus altitudinibus ad sui cuiusque dei decorem componantur. Altitudines autem earum sic sunt explicandae, uti Iovi omnibusque caelestibus quam excelsissimae constituentur, Vestae Terrae Marique² humiles conlocentur. Ita idoneae his institutionibus explicabuntur in meditationibus arearum³ deformationes.

Explicatis⁴ aedium sacrarum compositionibus in hoc libro, insequenti de communium operum reddemus distributionibus explicationes.

¹ d. immortalium immo potius demonum *S.*

² matrique *ed*: marique *H.*

³ ararum *G*: arearum *H.*

⁴ explicantis *H.*

BOOK IV. c. VIII.—c. IX.

tinguished from one another, as far as I could indicate by writing. Now I will speak of the precincts of the immortal gods so that they may have an arrangement suitable for the purposes of sacrifice.

CHAPTER IX

ON ALTARS

LET the altars look to the east¹ and be always placed lower than the images which shall be in the temple; so that those who pray and sacrifice may look up to the divinity from various levels as becomes each man's god. The levels of the altars to Jupiter and the host of heaven are so to be contrived that they may be placed as high as possible; to Vesta, Earth and Sea² they are to be made low. By these methods the planning of the precincts will be suitable in practice.

In this book the planning of temples has been explained. In the next book we shall give explanations about the arrangement of public buildings.

¹ The altar was outside the temple, in the precincts.

² Sea completes the four elements: air, fire, earth, water.

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BOOK V

•

LIBER QUINTUS

- 1 Qui amplioribus voluminibus, imperator, ingenii cogitationes praeceptaque explicaverunt, maximas et egregias adiecerunt suis scriptis auctoritates. Quod etiam vel in nostris quoque studiis res pateretur, ut amplificationibus auctoritas et in his praeceptis augeretur; sed id non est, quemadmodum putatur, expeditum. Non enim de architectura sic scribitur uti historia aut poemata. Historiae per se tenent lectores; habent enim novarum rerum varias expectationes. Poematorum vero carminum metra et pedes, ac verborum elegans dispositio et sententiarum inter personas distinctas, versuum pronuntiatio prolectando sensus legentium perducit sine offensa
- 2 ad summam scriptorum terminationem. Id autem in architecturae conscriptionibus non potest fieri, quod vocabula ex artis propria necessitate concepta inconsueto sermone obiciunt sensibus obscuritatem. Cum ergo ea per se non sint aperta nec pateant eorum in consuetudine nomina, tum etiam praeceptorum late evagantes¹ scripturae, si non contrahentur, et paucis et perlucidis sententiis explicentur, frequentia multitudineque sermonis inpediente incertas legentium efficient cogitationes. Itaque occultas nominationes commensusque e membris

¹ late vagantes *G*: lata evagantes *H*.

¹ For this meaning *cf.* *Vulg.* II. Thess. ii. 2.

BOOK V

PREFACE

1. MEN, Caesar, who in more ample volumes unfold the notions and rules suggested by their talent, add to their writings very great and unusual authority. Indeed even in our studies, the topic would allow this: namely, that in this treatise also, amplification would afford greater weight of authority. But that is not so convenient as it is thought. For writing about architecture is not like a history, or poems. Histories, of themselves, hold the reader. For they offer the varied prospects of novelty. Again in poems, the measures and feet of the music and the nice arrangement of words and opinions, the recital of verses distributed among the several characters, entice the thoughts¹ of the reader and, without hindrance, lead him on to the very close of the book. 2. But in architectural compositions this cannot take place. For the terms, used by the special necessity of the craft, by their unfamiliar sound seem obscure to the perception. Since therefore they of themselves are not obvious, nor is the nomenclature clear by customary use, so further the casual expression of rules—unless they are collected and explained in a few lucid phrases—renders uncertain the notions of the reader: for repetition and a cumbrous style are a hindrance. And while I enumerate, in accordance with the parts of buildings,

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operum pronuntians, ut memoriae tradantur, breviter exponam; sic enim expeditius ea recipere poterunt
 3 mentes. Non minus cum¹ animadvertissem distentam occupationibus civitatem publicis et privatis negotiis, paucis iudicavi scribendum, uti angusto spatio vacuitatis ea legentes breviter percipere possent.

Etiamque² Pythagorae quique³ eius haeresim fuerunt secuti, placuit cybicis rationibus praecepta in voluminibus scribere, constitueruntque cybum
 ccxvi⁴ versus eosque non plus tres in una conscrip-
 4 tione oportere esse putaverunt. Cybus autem est corpus ex lateribus aequali latitudine planitiarum perquadratus.⁵ Is cum est iactus, quam in partem incubuit, dum est intactus, inmotam habet stabilitatem, uti sunt etiam tesserae quas in alveo ludentes iaciunt. Hanc autem similitudinem ex eo sumpsisse videntur, quod is numerus versuum, uti cybus, in quemcumque sensum insederit, inmotam efficiat ibi memoriae stabilitatem. Graeci quoque poetae comici interponentes e choro canticum diviserunt spatia fabularum. Ita partes cybica ratione facientes
 intercapedinibus levant auctorum pronuntiationis.⁶

5 Cum ergo haec naturali modo sint a maioribus observata animoque advertam inusitatas et obscuras multis res esse mihi scribendas, quo facilius ad sensus legentium pervenire possint, brevibus voluminibus

¹ cum *G*: eum *H*. ² etiamque *Joc*: etiam qui *H*.

³ quique *G*: quinque *H*. ⁴ ccxvi *Joc*: cc. & l. *H*.

⁵ perquadratum *Joc*: -tus *H*.

⁶ pronuntiationis *H* (*c* = *t* in sc. 235 A.D.).

BOOK V. PREFACE

the obscure terms and measurements, I will expound them briefly so that they may be remembered. For thus the mind will be able to receive them more conveniently. 3. None the less, perceiving the state to be overstrained by public and private business, I decided that I must write briefly so that the reader might understand in his scanty leisure.

Pythagoras also, and those who followed his sect, decided to write their rules, cube fashion, in their volumes, and fixed upon a cube—216 lines¹—and they thought that not more than three cubes should be in one treatise. 4. Now a cube is a body with all its sides squared and their surfaces equal. When a cube is thrown, on whatever part it rests, it retains its stability unmoved so long as it is untouched, like the dice which players throw in a tray.² Now this analogy they seem to have taken from the fact that this number of verses, like a cube upon whatever sense it falls, makes the memory there stable and unmoved. Greek comic poets also, interposing the canticum³ sung by the chorus, divided the spaces of their plays. Thus making the parts cube fashion, they relieve by intervals the delivery of the author's words.

5. Since then, these things have been observed by our forefathers in the order of nature, and I find that I must deal with topics unfamiliar and obscure to the many, I decided to write in short compass, that they might more easily reach the

¹ *H* gives 250 ($250 = 2 \times 125 =$ a double cube; cf. Apollo's mathematical problem, Book IX. pref. 13). This gives 750 lines as the usual length of a book, *e.g.* of Homer.

² This seems to be quoted from Varro, Gell. I. xx. 6.

³ The sung portions which separate the dialogue.

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iudicavi scribere ; ita enim expedita erunt ad intelligendum. Eorumque ordinationes institui, uti non sint quaerentibus separatim colligenda, sed e corpore uno et in singulis voluminibus generum haberent explicationes. Itaque, Caesar, tertio et quarto volumine aedium sacrarum rationes exposui, hoc libro publicorum locorum expeditam dispositiones. Primumque forum uti oporteat constitui dicam, quod in eo et publicarum et privatarum rerum rationes per magistratus gubernantur.

I

- 1 GRAECI in quadrato amplissimis et duplicibus porticibus fora constituunt crebrisque columnis et lapideis aut marmoreis epistylliis adornant et supra ambulationes in contignationibus faciunt. Italiae vero urbibus non eadem est ratio faciendum, ideo quod a maioribus consuetudo tradita est gladiatoria
2 munera in foro dari. Igitur circum spectacula spatiosiora intercolumnia distribuuntur circaque in porticibus argentariae tabernae maenianaque superioribus coaxationibus conlocentur; quae et ad usum et ad vectigalia publica recta erunt disposita.

Magnitudines autem ad copiam hominum oportet fieri, ne parvum spatium sit ad usum aut ne propter

¹ There is probably a reference here to readers in a public library, such as that of Pollio on the Palatine, of which Varro was the first Director. Suet. *Julius* xlv.

² Forum at Tegea is square, Paus. VIII. 48.

³ Double colonnades at Elis, Paus. VI. 24.

⁴ Burn, *Rome* 90, Suet. *Julius* x. 1.

BOOK V. c. I.

perception of the reader. For so they will be convenient for understanding. And I fixed their arrangement so that the inquirer¹ has not to collect them, one by one, but that from one corpus and in the several books they might get the explanations of the several subjects. And so, Caesar, in the third and fourth volume, I explained the plans of temples; in this book I will set forth the arrangements of public places. And first I will say how the forum should be planned, because in it business, both of a public and private nature, is controlled by the magistrates.

CHAPTER I

ON THE FORUM AND BASILICA

1. THE Greeks plan the forum on the square² with most ample double³ colonnades and close-set columns; they ornament them with stone or marble architraves, and above they make promenades on the boarded floors. But in the cities of Italy we must not proceed on the same plan, because the custom of giving gladiatorial shows in the forum has been handed down from our ancestors.⁴ 2. For that reason more roomy intercolumniations are to be used round the spectacle; in the colonnades, silversmiths' shops⁵; and balconies, rightly placed for convenience and for public revenue, are to be placed on the upper floors.

The dimensions of the forum ought to be adjusted to the audience lest the space be cramped for use,

⁵ Or "bankers," offices previously occupied by schoolmasters, Liv. III. 44.

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inopiam populi vastum forum videatur. Latitudo autem ita finiatur uti, longitudo in tres partes cum divisa fuerit, ex his duae partes ei dentur;¹ ita enim erit oblonga eius formatio et ad spectaculorum
3 rationem utilis dispositio. Columnae superiores quarta parte minores quam inferiores sunt constituendae, propterea quod oneri ferendo quae sunt inferiora firmiora debent esse quam superiora. Non minus quod etiam nascentium oportet imitari naturam, ut in arboribus teretibus, abiete, cupresso, pinu, e quibus nulla non crassior est ab radicibus, dein decrescendo proceditur in altitudinem naturali contractura peraequata nascens ad cacumen. Ergo si natura nascentium ita postulat, recte est constitutum et altitudinibus et crassitudinibus superiora inferiorum fieri contractiora.

4 Basilicarum loca adiuncta foris quam calidissimis partibus oportet constitui, ut per hiemem sine molestia tempestatum se conferre in eas negotiatores possint. Earumque latitudines ne minus quam ex tertia, ne plus ex dimidia longitudinis constituentur, nisi si loci natura inpedierit et aliter coegerit symmetriam commutari. Sin autem locus erit amplior in longitudine, chalcidica in extremis constituentur, uti
5 sunt in Iulia Aquiliana. Columnae basilicarum tam altae, quam porticus latae fuerint, faciendae videntur; porticus, quam medium spatium futurum est, ex tertia finiatur. Columnae superiores minores quam inferiores, uti supra scriptum est, constituentur.

¹ ei dentur *Joc* : iubentur *H*.

¹ Public halls with nave, aisles, clerestory, later sometimes used as churches.

² Probably erected by Julius Caesar.

BOOK V. c. I.

or else, owing to a scanty attendance, the forum should seem too large. Now let the breadth be so determined that when the length is divided into three parts, two are assigned to the breadth. For so the plan will be oblong, and the arrangement will be adapted to the purpose of the spectacles. 3. The upper columns are to be a quarter less than the lower ones; because the lower columns ought to be stronger for bearing weight than the upper ones. Not less one ought also to imitate the natural growth of trees, as in tapering trees, the fir, the cypress, the pine, of which everyone is thicker at the roots. Then diminishing it rises on high, by a natural contraction growing evenly to the summit. Therefore since the nature of growing plants so demands, things are rightly arranged both in height and thickness, if the higher are more contracted than the lower.

4. The sites of basilicas¹ ought to be fixed adjoining the fora in as warm a quarter as possible, so that in the winter, business men may meet there without being troubled by the weather. And their breadth should be fixed at not less than a third, nor more than half their length, unless the nature of the site is awkward and forces the proportions to be changed. When the site is longer than necessary, the committee rooms are to be placed at the end of the basilica, as they are in the Basilica Julia² at Aquileia.³ 5. The columns of basilicas are to be of a height equal to the width of the aisle. The aisle is to have a width one third of the nave. The columns of the upper story are to be less than those below as herein above specified. The parapet

¹ Important commercial town near Venice.

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Pluteum, quod fuerit inter superiores et inferiores columnas, item quarta parte minus, quam superiores columnae fuerint, oportere fieri videtur, uti supra basilicae contignationem ambulantes ab negotiatoribus ne conspiciantur. Epistylia zophora coronae ex symmetriis columnarum, uti in tertio libro diximus, explicentur.

- 6 Non minus summam dignitatem et venustatem possunt habere comparationes basilicarum, quo genere Coloniae¹ Iuliae Fanestri conlocavi curavique faciendam, cuius proportiones et symmetriae sic sunt constitutae. Mediana testudo inter columnas est longa pedes cxx, lata pedes lx. Porticus eius circa testudinem inter parietes et columnas lata pedes xx. Columnae altitudinibus perpetuis cum capitulis pedes l, crassitudinibus quinum, habentes post se parastaticas altas pedes xx, latas² pedes ii s, crassas i s, quae sustinent trabes, in quibus invehuntur porticum contignationes. Supraque eas aliae parastaticae pedum xviii, latae binum, crassae pedem, quae excipiunt item trabes sustinentes cantherium et porticum, quae sunt summissa infra testudinem,
- 7 tecta. Reliqua spatia inter parastaticarum et columnarum trabes per intercolumnia luminibus sunt relictæ. Columnae sunt in latitudine³ testudinis cum angularibus dextra ac sinistra quaternae, in longitudine, quae est foro proxima, cum isdem angularibus octo, ex altera parte cum angularibus vi,⁴ ideo quod mediae duae in ea parte non sunt positae, ne inpediant aspectus pronai aedis Augusti, quae est in medio latere parietis basilicae conlocata spectans

¹ colonie G: columniae H.

² latas ed: latae H.

³ latitudine G: altitudine H.

⁴ vi H S: sex G.

BOOK V. c. I.

between the upper and lower columns ought to be one fourth less than the upper columns, so that people walking on the first floor may not be seen by persons engaged in business. The architraves, friezes and cornices are to be designed in accordance with the columns, as we have prescribed in the third book.

6. At the Julian Colony of Fano,¹ I let out for contract and superintended the building of a basilica not inferior to these in dignity and grace. Its proportions and harmonies are as follows: There is a vaulted nave between the columns 120 feet long and 60 broad. The aisle between the columns of the nave and the outside wall, is 20 feet wide. The columns are of an unbroken height, including the capitals, of 50 feet with a diameter of 5 feet. Behind them adjoining the aisle are pilasters 20 feet high, $2\frac{1}{2}$ feet wide and $1\frac{1}{2}$ feet thick. These carry the beams under the flooring. Above, there are pilasters 18 feet high, 2 feet wide and 1 foot thick, which take the beams which carry the principals of the main roof, and the roofs of the aisles which are lower than the vaulting of the nave. 7. The space which remains in the intercolumniations, above the pilasters and below the tops of the columns, admits the necessary lighting. In the width of the nave counting the angle columns right and left, there are four columns at each end. On the side adjoining the forum, there are eight, including the angle columns. On the other side there are six, including the angle columns. The two columns in the middle are omitted, so as not to obstruct the view of the pronaos of the Temple of Augustus which is situated in the middle of the side wall of the basilica and

¹ Founded by Augustus, see p. 317 n.

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8 medium forum et aedem Iovis. Item tribunal quod
est in ea aede, hemicycli schematis¹ minoris curva-
tura formatum; eius autem hemicycli in fronte est
intervallum pedes XLVI, introrsus curvatura pedes xv,
uti, qui apud magistratus starent, negotiantes in
basilica ne inpedirent. Supra columnas ex tribus
tignis bipedalibus compactis trabes sunt circa conlo-
catae, eaeque ab tertiis columnis quae sunt in in-
teriore parte, revertuntur ad antas quae a pronao
procurrunt, dextraque et sinistra hemicyclium tan-
9 gunt. Supra trabes² contra capitula ex fulmentis
dispositae pilae sunt conlocatae, altae pedes III, latae
quoqueversus quaternos. Supra eas ex duobus tignis
bipedalibus trabes everganeae circa sunt conlocatae.
Quibus insuper transtra³ cum capreolis columnarum
contra corpora et antas et parietes pronai conlocata⁴
sustinent unum culmen perpetuae basilicae, alterum
10 a medio supra pronauum aedis. Ita fastigiorum du-
plex tecti nata⁵ dispositio extrinsecus tecti et inte-
rioris altae testudinis praestat speciem venustam.
Item sublata epistyliorum ornamenta et pluteorum
columnarumque superiorum distributio operosam
detrahit molestiam sumptusque inminuit ex magna
parte summam. Ipsae vero columnae in altitudine
perpetua sub trabe testudinis perductae et magnifi-
centiam impensae et auctoritatem operi adaugere
videntur.

¹ scematis *H.*

² trabes *H.*

³ transtra *rec*: trasta *H.*

⁴ collocata *Joc*: -tae *H.*

⁵ pectinata *Bondam*: tectinata *H.* Cic. *Q.F.* III. i. 14.

BOOK V. c. I.

faces the middle of the forum and the Temple of Jupiter. 8. The tribunal which is in the former temple, is in the shape of the segment of a circle. The width of the segment in front is 46 feet; its depth is 15 feet; so that those who come before the magistrates may not interfere with persons on business in the basilica. Above the columns are beams made of three 2 foot joists bolted together. These return from the third column on either side of the opening to the antae of the pronaos, and adjoin the curve of the tribunal right and left. 9. Above the beams vertically over the capitals, piers are placed on supports, 3 feet high and 4 feet square. Above them, beams formed of two 2 foot joists, carefully wrought, are carried round the basilica. Thereon over against the shafts of the columns, and the antae and walls of the pronaos, cross-beams and struts support the whole ridge of the basilica, and a second ridge running out from the middle of the main ridge, over the pronaos of the temple. 10. Thus there arises from the roof a double arrangement of gables. This gives a pleasing effect both to the exterior of the roof and to the high vaulting within. Further, we dispense with the ornaments of the entablatures and the provision of the upper columns and parapets. We are relieved from laborious details and escape a large expenditure, while the carrying up of the columns without a break to the beams of the vault¹ seems to give a sumptuous magnificence and impressiveness to the work.

¹ This anticipates the Palladian use of columns as in the Redentore at Venice.

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II

- 1 AERARIUM, carcer, curia foro sunt coniungenda, sed ita uti magnitudo symmetriae eorum foro respondeant. Maxime quidem curia in primis est facienda ad dignitatem municipii sive civitatis. Et si quadrata erit, quantum habuerit latitudinis dimidia addita constituatur altitudo; sin autem oblonga fuerit, longitudo et latitudo componatur, et summae compositae¹ eius dimidia pars sub lacunaris² altitudini detur. Praeterea praecingendi sunt parietes medii coronis ex intestino opere aut albario ad dimidiam partem altitudinis. Quae si non erunt, vox ibi disputantium elata in altitudinem intellectui non poterit esse audientibus. Cum autem coronis praecincti parietes erunt, vox ab imis morata priusquam in aera elata dissipabitur, auribus erit intellecta.

III

- 1 Cum forum constitutum fuerit, tum deorum immortalium diebus festis ludorum expectationibus³ eligendus est locus theatro quam saluberrimus, uti in primo libro de salubritatibus in moenium conlocationibus est scriptum. Per ludos enim cum coniugibus et liberis persedentes delectationibus detinentur et corpora propter voluptatem inmota patentes

¹ compositae G^e: -ta H.

² lacunaris H: cf. sociis = sociis; operaris = operariis (Pompeii).

³ expectator idem quod spectator.

¹ Albarium is the finishing coat of stucco.

BOOK V. c. II.—c. III.

CHAPTER II

ON THE TREASURY, PRISON, AND CURIA

1. THE treasury, prison, senate-house are to adjoin the forum but in such a way that their scale and proportion answers to that of the forum. In the first place especially the senate-house is to be built with a view to the dignity of the municipality or city. If it be square its height must be one and a half times its width; but if it be oblong, let the length and breadth be added together and let half of the total amount be given to the height under the ceiling. 2. Moreover the interior walls are to be surrounded half way up with cornices of fine joiners' work or plaster¹ at half their height. If this is not done, the voice of the disputants rising upwards cannot be understood by the audience. When, however, the walls are girt with cornices, the voice, being delayed by the lowest parts before it rises into the air and is scattered, will be perceived by the ear.

CHAPTER III

ON THE SITE OF THE THEATRE

1. WHEN the forum has been settled, a site as healthy as possible is to be chosen for the exhibition of plays on the festivals of the immortal gods, according to the instructions given in the first book for the healthy disposition of the city walls. For at the play citizens with their wives and children remain seated in their enjoyment; their bodies motionless with pleasure have the pores opened.

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habent venas, in quas insiduntur aurarum flatus, qui, si a regionibus palustribus aut aliis regionibus vitiosis¹ advenient, nocentes spiritus corporibus infundent. Itaque si curiosius eligitur locus theatro, vitabuntur
 2 vitia. Etiamque providendum est, nene impetus habeat a meridie. Sol enim cum implet eius rutilantem, aer conclusus curvatura neque habens potestatem vagandi versando confervescit et candens adurit excoquitque et inminuit e corporibus umores. Ideo maxime vitandae sunt his rebus vitiosae regiones
 3 et eligendae salubres. Fundamentorum autem, si in montibus fuerit, facilius erit ratio; sed si necessitas coegerit in plano aut palustri loco ea constitui, solidationes substructionesque ita erunt faciendae, quemadmodum de foundationibus aedium sacrarum in tertio libro est scriptum. Insuper fundamenta lapideis et marmoreis copiis gradationes ab substructione
 4 fieri debent. Praecinctiones ad altitudines theatrorum pro rata parte faciendae videntur, neque altiores quam quanta praecinctionis itineris sit latitudo. Si enim excelsiores fuerint, repellent et eicient in superiorem partem² vocem nec patientur³ in sedibus suis, quae⁴ supra praecinctiones, verborum casus certa significatione ad aures pervenire. Et ad summam ita est gubernandum, uti, linea cum ad inum gradum et ad summum extenta fuerit, omnia cacumina graduum angulosque tangat; ita vox non

¹ viciosis *H.*

² eicientem superiorem partem *H.*

³ patientur *H.*

⁴ *H om. verbum.*

¹ By preference theatres were excavated in the side of a hill as at Dougga near Carthage. Greek theatres are often on the hill side; Roman theatres, on the level.

² Vitruvius often uses a singular verb referring to the main

BOOK V. c. III.

On these the breath of the wind falls, and if it comes from marshy districts or other infected quarters, it will pour harmful spirits into the system. If therefore special care is taken in choosing a site, infection will be avoided. 2. Care also is to be taken, lest it be open to attacks from the south. For when the sun fills the circuit of the theatre, the air being enclosed within the curved space and not having the opportunity of circulating, revolves and becomes heated; hence it blazes, burns up, draws out and reduces the moisture of the body. Thus sites which are faulty in these respects are especially to be avoided, and healthy sites chosen.¹ 3. If the theatre is² on a hillside, the construction of the foundations will be easier. But if they have to be laid on level or marshy ground, piles and substructures must be used as we have written in the third book concerning the foundations of temples. Above the foundations, the stepped seats ought to be built up from the substructure in stone or marble. 4. The curved level gangways, it seems, should be made proportionately to the height of the theatre; and each of them not higher at the back, than is the breadth of the passage of the gangway. For if they are taller, they will check and throw out the voice into the upper part of the theatre. Neither will they allow the endings of words to come with a clear significance to the ears of the people in their seats above the gangways. In brief the section of the theatre is to be so managed that if a line is drawn touching the lowest and the top rows, it shall also touch the front angles of all the rows. Thus the topic. It is unnecessary, here as elsewhere, to correct the MSS.

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5 inpedietur. Aditus complures et spatiosos oportet disponere, nec coniunctos superiores inferioribus, sed ex omnibus locis perpetuos et directos sine ¹ inversuris faciendos, uti, cum populus dimittatur de spectaculis, ne comprimatur, sed habeat ex omnibus locis exitus separatos sine inpeditione.

Etiam diligenter est animadvertendum, ne sit locus surdus, sed ut in eo vox quam clarissime vagari possit. Hoc vero fieri ita poterit, si locus electus 6 fuerit, ubi non inpediantur resonantia. Vox autem ut spiritus fluens aeris, et actu sensibilis auditu. Ea movetur circulorum rutundationibus infinitis, uti si in stantem aquam lapide inmisso nascentur innumerabiles undarum circuli crescentes a centro, quam latissime possint, et vagantes, nisi angustia loci interpellaverit aut aliqua offensio, quae non patitur designationes earum undarum ad exitus pervenire. Itaque cum interpellentur offensionibus, primae redundantes insequentium disturbant designationes. 7 Eadem ratione vox ita ad circum efficit motiones; sed in aqua ² circuli planitiae in latitudine moventur, vox et in latitudine progreditur et altitudinem gradatim scandit. Igitur ut in aqua undarum designationibus, item in voce cum offensio nulla primam undam interpellaverit, non disturbat secundam ³ nec

¹ sine *rec* : siue *H*.

² in aquâ *H*.

³ secundâ *G* : -dum *H*.

¹ *actu* is an Aristotelian term, = actual.

² This comparison is made by the Stoics, Dio L. VII. 158; Plut. *Plac. Phil.* IV. xix. 4.

BOOK V. c. III.

voice will not be checked. 5. Many and spacious stepped passages must be arranged between the seats; but the upper ones ought to be discontinuous with the lower. Everywhere, each passage (upper or lower) must be continuous and straight without bends; so that when the audience is dismissed from the spectacle, it may not be cramped, but may find everywhere separate and uninterrupted exits.

Great care is also to be taken that the place chosen does not deaden the sound, but that the voice can range in it with the utmost clearness. And this can be brought about if a site is chosen where the passage of sound is not hindered. 6. Now the voice is like a flowing breath of air, and is actual¹ when perceived by the sense of hearing. It is moved along innumerable undulations of circles; as when² we throw a stone into standing water. Innumerable circular undulations arise spreading from the centre as wide as possible. And they extend unless the limited space hinders, or some obstruction which does not allow the directions of the waves to reach the outlets. And so when they are interrupted by obstacles, the first waves flowing back disturb the directions of those which follow. 7. In the same way the voice in like manner moves circle fashion. But while in water the circles move horizontally only, the voice both moves horizontally and rises vertically by stages.³ Therefore as is the case with the direction of the waves in water, so with the voice when no obstacle interrupts the first wave, this in turn does not disturb the second and later

³ The Stoics noted that the undulations of sound moved "spherically" through the air, and not merely horizontally. *Plut. loc. cit.*

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insequentes, sed omnes sine resonantia perveniunt
8 ad imorum et ad summorum aures. Ergo veteres
architecti naturae vestigia persecuti indagationibus
vocis scandentis¹ theatrorum perfecerunt gradationes,
et quaesierunt per canonicam mathematicorum et
musicam rationem, ut, quaecumque vox esset in
scaena, clarior et suavior ad spectatorum perveniret
aures. Uti enim organa in aeneis lamminis aut
corneis *echeis*² ad cordarum³ sonitum claritatem
perficiuntur, sic theatrorum per harmonicen ad
augendam vocem ratiocinationes ab antiquis sunt
constitutae.

IV

1 HARMONIA autem est musica litteratura obscura et
difficilis, maxime quidem quibus graecae litterae non
sunt notae. Quam si volumus explicare, necesse est
etiam graecis verbis uti, quod nonnullae eorum latinas
non habent appellationes. Itaque ut potuero quam
apertissime ex Aristoxeni scripturis interpretabor et
eius diagramma subscribam finitionesque sonituum
designabo, uti, qui diligentius attenderit, facilius
2 percipere possit. Vox enim mutationibus cum
flectitur, alias fiat acuta, alias gravis; duobusque
modis movetur, e quibus unus effectus habet continu-
atos, alter distantis. Continuata vox neque in finitio-
nibus consistit neque in loco ullo, efficitque termina-
tiones non apparentes, intervalla autem media

¹ vocis scandentis *G^c*: voces scandentes *H*.

² *ἡχείους Schm*: haeae sic *H*.

³ corda Petr. 66, 7; sonitum *gen. nl*.

¹ As reverberators.

BOOK V. C. III.—C. IV.

waves, but all reach the ears of the top and bottom rows without echoing. Therefore the ancient architects following nature's footsteps, traced the voice as it rose, and carried out the ascent of the theatre seats. By the rules of mathematics and the method of music, they sought to make the voices from the stage rise more clearly and sweetly to the spectators' ears. For just as organs which have bronze plates¹ or horn sounding boards are brought to the clear sound of string instruments, so by the arrangement of theatres in accordance with the science of harmony, the ancients increased the power of the voice.

CHAPTER IV

ON HARMONY

1. HARMONY is an obscure and difficult branch of musical literature especially for persons unacquainted with Greek. If we wish to explain it we must use Greek words and some of these have no Latin renderings. Therefore I shall translate (as well as I can) from the works of Aristoxenus² subjoining his diagram, and I shall indicate the definitions of the musical notes, so that an attentive reader can the more easily understand. 2. For when the voice is changed and modulated it may sometimes become high, sometimes low. It moves in two manners, of which one is continuous, the other by intervals. For the continuous voice neither stops in definite notes nor indeed anywhere, and comes to no clear endings. There are, however, intervals apparent between one

² Pupil of Aristotle. Some of his musical works have come down.

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parentia, uti sermone cum dicamus : sol lux flos vox. Nunc enim nec unde incipit nec ubi desinit, intelligitur; sed quod ex acuta facta est gravis et ex gravi acuta, apparet auribus. Per distantiam autem e contrario. Namque cum flectitur, inmutatione vox statuit se in alicuius sonitus finitionem, deinde in alterius, et id ultro citro crebre faciendo constans apparet sensibus, uti in cantionibus cum flectentes vocem varietatem facimus. Modulationis itaque intervallis¹ ea cum versatur, et unde initium fecit et ubi desiit, apparet in sonorum patentibus finitionibus, mediana autem patentia intervallis obscurantur.

- 3 Genera vero sunt modulationum tria : primum quod Graeci nominant *harmoniam*, secundum *chroma*, tertium *diatonon*. Est autem harmoniae modulatio ad artem concepta, et ea re cantio eius maxime gravem et egregiam habet auctoritatem. Chroma subtili sollertia ac crebritate modulorum suaviorem habet delectationem. Diatoni vero, quod naturalis est, facilius est intervallorum distantia. In his tribus generibus dissimiles sunt tetrachordorum dispositiones, quod harmonia tetrachordorum et tonos et dihexis habet binas (dihexis autem est toni pars quarta; ita in hemitonio duae dihexes sunt conlocatae); chromati duo hemitonio in ordine sunt composita, tertium trium hemitoniorum est intervallum; diatono² toni duo sunt continuati, tertium hemitonium finit tetrachordi magnitudinem. Ita in

¹ intervalles *H.*

² *add. Lor.*

¹ That is taking definite notes at definite intervals.

² Or "enharmonic," introduces quarter tones as when we divide the interval between E and F.

³ Introduces more subtle intervals even than the quarter tone.

BOOK V. c. iv.

sound and the next; as when we say: *sol lux flos vox*. For now it is not perceived whence it begins nor where it ceases. But that it passes from high to low, and from low to high, is heard by the ears. The case is opposite with intervals. For when the voice is modulated, the voice in changing is directed first to one determinate sound and then to another. Doing this often backwards and forwards it appears consistent¹ to the sense of hearing, as when in singing we modulate the voice in various ways. When therefore the voice is modulated by intervals, the manifest limits of the notes make clear where it begins and where it breaks off; but the notes within the intervals, although clear in themselves, are not heard.

3. The kinds of modulation are three: first that which the Greeks call *harmonia*; second *chroma*; third *diatonon*. Now harmonic modulation² is artificially constructed; singing in this style has a very solemn and impressive influence. Chromatic³ modulation, by the refinement and "closeness" of its transitions, produces an impression of more sweetness. The diatonic modulation is closer to nature and has a more easy distance of its intervals. In these three scales, the arrangements of the tetrachords differ. The harmonic scale has two tones in the tetrachord and two quarter-tones. (Now two quarter-tones make a semitone.) The chromatic tetrachord⁴ has two consecutive semitones and the third interval is of three semitones. The diatonic tetrachord⁴ has two consecutive tones, and the third interval—a semitone—completes the amount of the

⁴ e.g. C D E F.

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tribus generibus tetrachorda ex duobus tonis et hemitonio sunt¹ peraequata, sed ipsa cum separatim uniuscuiusque generis finibus considerantur, dissimilem habent intervallorum designationem.

4 Igitur intervallo tonorum et hemitoniorum et tetrachordorum in voce divisit natura finitque terminationes eorum mensuris intervallorum quantitate, modisque certis distantibus constituit qualitates, quibus etiam artifices qui organa fabricant, ex natura constitutis utendo comparant ad concentus convenientes eorum perfectiones.

5 Sonitus, qui graece *phthongi*² dicuntur, in unoquoque genere sunt x et viii, e quibus viii sunt in tribus generibus perpetui et stantes, reliqui x, cum communiter modulantur, sunt vagantes. Stantes autem sunt, qui inter mobiles sunt interpositi. Continent tetrachordi coniunctionem et e generum discriminibus suis finibus sunt permanentes; appellantur autem sic: proslambanomenos,³ hypate hypaton,⁴ hypate meson,⁵ mese, nete synhemmenon,⁶ paramese, nete diezeugmenon,⁷ nete hyperbolaeon. Mobiles autem sunt, qui in tetrachordo inter inmotos dispositi in generibus ex⁸ locis loca mutant; vocabula autem habent haec: parhypate hypaton, lichanos hypaton, parhypate meson, lichanos meson, trite synhemmenon, <paranete synhemmenon,>⁹ trite diezeugmenon, paranete die-

¹ sunt *G*: *om.* *H.*

² *phthongi H.*

³ *iros lambanomenos H.*

⁴ *hypate hypato H.*

⁵ *hypatemeson G*: *hypateon meson H.*

⁶ *nete synemmene H.*

⁷ *diezeugmene G.*

⁸ *ex Ro*: et (&) *H.*

⁹ *add. Joc., qui haec omnia correxit.*

¹ *e.g.*: in modern music the *quantity* of the intervals in major and minor scales is the same, but the *quality* of major and minor is different.

BOOK V. c. iv.

tetrachord. Thus in the three scales the tetrachords are equivalent to two tones and a half, but when they are considered separately within the limits of each scale, they vary in the arrangement of the intervals.

4. Therefore by the intervals of tones, semitones, and tetrachords, nature has divided and defined their limits for the voice, measuring them by the *quantity* of the intervals; and has fixed their *quality*¹ in certain distinct modes. Craftsmen who make instruments use these proportions which nature has fixed, and make perfect their instruments with a view to suitable concords.²

5. Sounds (which in Greek are called *phthongi*) are eighteen in number for each kind.³ Of these, eight are perpetually fixed in the three kinds; the remaining ten, when they are modulated in common, are found to vary. Now those are fixed which are interposed between the variable sounds; they determine the combination of the tetrachord, and in accordance with the differences of the kinds remain in their own limits. Their names are these: *proslambanomenos*; *hypatè hypatōn*; *hypatè mesōn*; *mesè*; *nētè synhēmmenōn*; *paramesè*; *nētè diezeugmenōn*; *nētè hyperbolaeōn*. Those sounds are shifting which are arranged in the tetrachord between the fixed sounds, and change from place to place in the three kinds. Their names are these: *parhypatè hypatōn*; *lichanos hypatōn*; *parhypatè mesōn*; *lichanos mesōn*; *tritè synhēmmenōn*; *paranētè synhēmmenōn*; *tritè diezeugmenōn*; *paranētè die-*

² This is heard in the adjustment of the tones of *pianos* so as to fit all scales (temperament).

³ The figure will indicate the meaning of these technical terms: Plate F.

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zeugmenon, trite hyperbolaeon, paranete hyper-
6 bolaeon. Ei autem qua moventur, recipiunt virtutes
alias; intervalla enim et distantias habent crescentes.
Itaque parhypate, quae in harmonia distat ab hypate
<dimidium>¹ hemitonium, in chroma tramutata²
habet hemitonium. Qui³ lichanos in harmonia
dicitur, ab hypate distat hemitonium, in chroma
translata progreditur duo hemitonia, in diatono distat
ab hypate tria hemitonia. Ita x sonitus propter
translationes in generibus efficiunt triplicem modu-
lationum varietatem. Tetrachorda autem sunt quin-
7 que: primum gravissimum, quod graece dicitur
hypaton, secundum medianum, quod appellatur
meson, tertium coniunctum, quod *synhemmenon* dicitur,
quartum disiunctum, quod *diezeugmenon* nominatur,
quintum, quod est acutissimum, graece *hyperbolaeon*
dicitur. Concentos quos natura hominis modulari
potest, graece quae *synphoniae* dicuntur, sunt sex:
diatessaron, diapente, diapason, et disdiatessaron, et
8 disdiapente, et disdiapason. Ideoque et a numero
nomina ceperunt, quod, cum vox constiterit in una
sonorum finitione ab eaque se flectens mutaverit
et pervenerit in quartam terminationem, appellatur
diatessaron, in quintam diapente⁴ [in sextam diapason
in octavam et dimidiam diapason et diatessaron, in
nonam et dimidiam diapason diapente, in xii dis-
9 diapason]. Non enim inter duo intervalla, cum
chordarum sonitus aut vocis cantus factus fuerit, nec
in tertia aut sexta aut vii⁵ possunt consonantiae
fieri, sed, uti supra scriptum est, diatessaron et

¹ *add. Mar.* ² chromatra mutata H. cf. tranatare.

³ quae Lor: qui H. ⁴ sqq. del. Wilmanns.

⁵ septem H: vii ed.: septima e₂.

BOOK V. c. iv.

zeugmenōn; tritè hyperbolaeōn; parenētè hyperbolaeōn. 6. But those sounds which shift, gain various qualities; for they have increasing intervals and distances. Thus the parhypatè which in the enharmonic is half a semitone from the hypatè, has a semitone when it is changed to the chromatic. What is called lichanos in the enharmonic kind, is distant a semitone from the hypatè; transferred to the chromatic, it advances two semitones; in the diatonic, it is distant three semitones. Thus the 10 sounds, because of their transpositions in the three scales, produce a triple variety of modulation. 7. Now the tetrachords are five: the first is the lowest which in Greek is called *hypaton*; the second is the middle which is called *meson*; the third which is joined to these is called *synhēmmenon*; the fourth being separated is called *diezeugmenon*; the fifth which is the highest is called in Greek *hyperbolaeon*. The concords (in Greek *symphoniae*) which the human voice can modulate are six: diatessaron (fourth); diapente (fifth); diapason (octave); disdiatessaron (octave and fourth); disdiapente (octave and fifth); disdiapason (two octaves). 8. These have taken their names from numbers. For when the voice has rested in one fixed sound, and then modulates and changes from itself, and comes to the fourth sound it is called diatessaron; when it comes to the fifth, it is called diapente; [to the eighth, diapason; to the eleventh, diapason with diatessaron; to the twelfth, diapason with diapente to the fifteenth disdiapason]. 9. For concords cannot arise between two intervals, when the sound of strings or the song of the voice is uttered, nor between three or six or seven; but, as we wrote above, the diatessaron and diapente up to

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diapente et ex ordine disdiapason convenientiae ex natura vocis congruentis habent finitiones. Et ei coventus¹ procreantur ex coniunctione sonituum, qui graece *phthongi* dicuntur.

V

- 1 ITA ex his indagationibus mathematicis rationibus fiant vasa aerea pro ratione magnitudinis theatri, eaque ita fabricentur, ut, cum tangantur, sonitum facere possint inter se diatessaron diapente ex ordine ad disdiapason. Postea inter sedes theatri constitutis cellis ratione musica ibi conlocentur ita, uti nullum parietem tangant circaque habeant² locum vacuum et ab summo capite spatium, ponanturque inversa et habeant² in parte, quae spectat ad scaenam, suppositos cuneos ne minus altos semipede; contraque eas cellas relinquantur aperturae inferiorum graduum³
- 2 cubilibus longae pedes duo, altae semipede. Designationes autem eorum, quibus in locis constituentur, sic explicentur. Si non erit ampla magnitudine theatrum, media altitudinis transversa regio designetur et in ea tredecim cellae duodecim aequalibus intervallis distantes conformicentur, uti ea echea⁴ quae supra scripta sunt, ad neten⁵ hyperbolaeon sonantia⁶ in cellis quae sunt in cornibus extremis, utraque parte prima conlocentur, secunda ab extremis

¹ cf. coventio *S. C. Bacch.*

² locum . . . habeant *bis ponit H.*

³ graduu *G: gradibus H.*

⁴ ea echea *Joc: eae echo H.*

⁵ netent *H.* ⁶ sonentia *H.*

BOOK V. c. iv.—c. v.

the disdiapason are concords which have limits arising from the nature of the voice. And these concords are produced from the conjunction of sounds which in Greek are called *phthongi*.

CHAPTER V

ON SOUNDING VASES IN THEATRES

1. HENCE in accordance with these enquiries, bronze¹ vases are to be made in mathematical ratios corresponding with the size of the theatre. They are to be so made that, when they are touched, they can make a sound from one to another of a fourth, a fifth and so on to the second octave. Then compartments are made among the seats of the theatre, and the vases are to be so placed there that they do not touch the wall, and have an empty space around them and above. They are to be placed upside down. On the side looking towards the stage, they are to have wedges put under them not less than half a foot high. Against these cavities openings are to be left in the faces of the lower steps two feet long and half a foot high. 2. The planning of them and the places in which they are to be are to be thus set forth. If the theatre is not of large dimensions, in the middle of the height, a transverse line is to be drawn. In that, thirteen cavities separated by twelve equal distances are to be arched over, so that those vases above referred to, giving the note of the *nētè hyperbolaeōn*, may be placed at each end; second from the end, vases of the *nētè diezeug-*

¹ Earthenware vases, apparently for this purpose, have been found in ancient theatres, but not bronze vases.

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diatessaron ad neten diezeugmenon,¹ tertia diatessaron ad paramesen,² quarta ad neten synhemmenon, quinta diatessaron ad mesen, sexta diatessaron ad hypaten meson, in medio unum diatessaron ad
 3 hypaten hypaton. Ita hac ratiocinatione vox a scaena uti ab centro profusa se circumagens tactuque feriens singulorum vasorum cava excitaverit auctam claritatem et³ concentu convenientem sibi consonantiam. Sin autem amplior erit magnitudo theatri, tunc altitudo dividatur in partes IIII, uti tres efficiantur regiones cellarum transverse designatae, una harmoniae, altera chromatos, tertia diatoni. Et ab imo quae erit prima, ea ex harmonia conlocetur,
 4 ita uti in minore theatro supra scriptum est. In mediana autem prima in extremis cornibus ad chromaticen hyperbolaeon habentia sonitum ponantur, in secundis ab his diatessaron ad chromaticen diezeugmenon, in tertiis ad chromaticen synhemmenon,⁴ quartis diatessaron ad chromaticen meson, quintis diatessaron ad chromaticen hypaton, sextis ad paramesen, quod et in chromaticen hyperbolaeon diapente et ad chromaticen meson diatessaron habeant consonantiae com-
 5 munitatem. In medio nihil est conlocandum, ideo quod sonitum nulla alia qualitas in chromatico genere symphoniae consonantiam potest habere. In summa vero divisione et regione cellarum in cornibus primis ad diatonon hyperbolaeon fabricata vasa sonitu ponantur, in secundis diatessaron ad diatonon <diezeugmenon>,⁵ tertiis⁶ ad diatonon synhemmenon,

¹ diezeugmenon *Joc* : synhemmenu *H*.

² ad paramesen *Perr* : adnethen ad paramesen *H*.

³ et *Joc* : ex *H*.

⁴ in tertiis ad chrom. synhemmenon *Lor* : in tertiis diatessaron ad chrom. synhemmenu *H*.

⁵ *add. ed. Ven.*

⁶ tertiis ad diatonon *Lor* : tertiis diatessaron ad diatonum *H*.

BOOK V. c. v.

menōn at an interval of one fourth from the last; third from the end at the paramesè (another fourth); the fourth set of vases at the nētè synhemmenōn; the fifth at the mesè (interval of a fourth); the sixth set at the hypatè mesōn (interval of a fourth); in the middle one vase at the hypatè hypatōn. 3. Thus by this calculation the voice, spreading from the stage as from a centre and striking by its contact the hollows of the several vases, will arouse an increased clearness of sound, and, by the concord, a consonance harmonising with itself. But if the theatre is larger, then the height is to be divided into 4 parts, so that three lines of cavities are drawn crosswise, one enharmonic, a second chromatic, the third diatonic. The first from the bottom is to be arranged for the enharmonic kind as described above for the smaller theatre. 4. In the middle series on the extreme wings, the first vases are to be put with a note of the chromatic hyperbolæon; in the second cavities at the interval of a fourth, the chromatic diezeugmenon; in the third the chromatic synhēmmenon; in the fourth cavities, at the interval of a fourth, the chromatic meson; in the fifth at the interval of a fourth the chromatic hypaton; in the sixth the paramesè, which has a fifth interval to the chromatic hyperbolæon, and an interval of a fourth to the chromatic synhēmmenon. 5. In the centre nothing is to be put, because no other quality of sound has a share in the concords of the chromatic kind. In the top¹ division and line of cavities, vases are to be put in the extreme wings, made to sound the diatonic hyperbolæon; in the second at the interval of a fourth the diatonic diezeugmenon; in the third the diatonic synhēmmenon; in the fourth (at the interval of a fourth) the

¹ See Plate F.

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quartis diatessaron ad diatonon meson, quintis diatessaron ad diatonon hypaton, sextis diatessaron ad proslambanomenon, in medio ad mesen, quod ea et ad proslambanomenon diapason et ad diatonon hypaton
6 diapente habet symphoniarum communitates. Haec autem si qui voluerit ad perfectum facile perducere, animadvertat in extremo libro diagramma musica ratione designatum, quod Aristoxenus magno vigore et industria generatim divisis modulationibus constitutum reliquit, de quo, si qui ratiocinationibus his attenderit, ad naturas vocis et audientium delectationes facilius valuerit theatrorum efficere perfectiones.
7 Dicet aliquis forte multa theatra quotannis Romae facta esse neque ullam rationem harum rerum in his fuisse; sed errabit.¹ in eo, quod omnia publica lignea theatra tabulationes habent complures, quas necesse est sonare. Hoc vero licet animadvertere etiam ab citharoedis qui, superiore tono cum volunt canere, avertunt se ad scaenae valvas² et ita recipiunt ab earum auxilio consonantiam vocis. Cum autem ex solidis rebus theatra constituuntur, id est ex structura caementorum, lapide,³ marmore, quae sonare non possunt, tunc echeis⁴ hae rationes sunt
8 explicandae. Sin autem quaeritur, in quo theatro ea sint facta, Romae non possumus ostendere, sed in Italiae regionibus⁵ et in pluribus Graecorum civitatibus. Etiamque auctorem habemus Lucium Mumium qui diruto theatro Corinthiorum ea aenea

¹ errabit *Phil*: erravit *H*. ² valbas *H*.

³ lapido *H*. ⁴ echeis *Ro*: exhis *H*.

⁵ regionibus *Joc (rec)*: regiones *H*.

¹ *cf.* Plate F.

² These were wooden erections. Pompey was attacked for building a permanent stone theatre. Similarly the temporary
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BOOK V. c. v.

diatonic meson; in the fifth at the interval of a fourth at the diatonic hypaton; in the sixth at the interval of a fourth the proslambanomenos; in the middle the mesè, between which and the proslambanomenos is an octave, and a fifth to the diatonic hypaton. 6. If anyone wishes to bring all this to execution, let him note at the end of the book a diagram¹ drawn in accordance with the method of music, which Aristoxenus, employing a sound and careful method, has left to us arranged with the modulations according to their kinds. If he attends to these calculations, he will the more easily be able to erect theatres adapted to the nature of the voice and the pleasure of the audience.

7. Someone will say, perhaps, that many theatres² are built every year at Rome without taking any account of these matters. He will be mistaken in this. All public wooden theatres have several wooden floors which must naturally resound. We can observe this also from those who sing to the zither, who when they wish to sing with a louder tone, turn to the wooden scenery, and, with this help, gain resonance for their voice. But when theatres are built of solids, that is of rubble walling, stone or marble which cannot resound, the use of bronze vases is to be followed. 8. But if you ask in what theatre this is done, we cannot show any at Rome, but we must turn to the regions of Italy, and to many Greek cities. We find a precedent in Lucius Mummius³ who destroyed the theatre at Corinth, and transported

structures had been attacked for affording seats to the spectators who were thereby encouraged to spend the day in idleness. Tac. *Ann.* XIV. 20.

³ B.C. 146.

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Romam deportavit et de manubiis ad aedem Lunae dedicavit. Multi etiam sollertes architecti, qui in oppidis non magnis theatra constituerunt, propter inopiam fictilibus doleis ita sonantibus electis hac ratiocinatione compositis perfecerunt utilissimos effectus.

VI

- 1 IPSIUS autem theatri conformatio sic est facienda, uti, quam magna futura est perimetros imi, centro medio conlocato circumagatur linea rutundationis,¹ in eaque quattuor scribantur trigona paribus² lateribus; intervallis extremam lineam circinationis,³ tangant, quibus etiam in duodecim signorum caelestium astrologia⁴ ex musica convenientia astrorum ratiocinantur. Ex his trigonis cuius latus fuerit proximum scaenae, ea regione, qua⁵ praecidit curvaturam circinationis, ibi finiatur⁶ scaenae frons, et ab eo loco per centrum parallelos linea ducatur, quae disiungat² proscaenii pulpitem et orchestrae regionem. Ita latius factum fuerit pulpitem quam Graecorum, quod omnes artifices in scaena⁷ dant operam, in orchestra autem senatorum sunt sedibus loca designata. Et eius pulpiti altitudo sit ne plus pedum quinque, uti, qui in orchestra sederint, spectare possint omnium agentium gestus. Cunei spectaculorum in theatro ita dividantur, uti anguli trigonorum, qui

¹ rutundationes *H.*

² partibus *H.*

³ circinnationes *H.*

⁴ astrologia *Lor*: astrologi *H.*

⁵ qua *Joc*: quae *H.*

⁶ finiantur *H.*

⁷ caena *H.*

¹ On the Aventine, destroyed in the Neronian fire. Tac. *Ann.* XV. 41. Piatner 320.

BOOK V. c. v.-c. vi.

these bronze vessels to Rome, and dedicated them, from the spoils, at the temple of Luna.¹ Further many clever architects, who in towns of moderate size have built theatres, have chosen, for cheapness' sake, earthenware vessels with similar sounds, and arranging them in this way have produced very useful effects.

CHAPTER VI

ON THE PLANNING OF THEATRES

1. THE plan ² of the theatre is to be thus arranged: that the centre is to be taken, of the dimension allotted to the orchestra at the ground level. The circumference is to be drawn; and in it four equilateral triangles are to be described touching the circumference at intervals (just as in the case of the twelve celestial signs, astronomers calculate from the musical division of the constellations). Of these triangles the side of that which is nearest the scene, will determine the front of the scene, in the part where it cuts the curve of the circle. Through the centre of the circle a parallel line is drawn which is to divide the platform of the proscenium from the orchestra. 2. Thus the stage will be made wider than that of the Greeks because all the actors play their parts on the stage, whereas the orchestra is allotted to the seats of the senators.³ The height of the stage is not to be more than 5 feet, so that those who are seated in the orchestra can see the gestures of all the actors. The blocks of seats in the theatre are so to be divided that the angles of the

² Plate G shows the plan of a small theatre.

³ The Greek chorus was in the orchestra.

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currunt circum curvaturam circinationis,¹ dirigant
 ascensus scalasque inter cuneos ad primam praecincin-
 tionem; supra autem alternis itineribus superiores
 3 cunei medii dirigantur. Hi autem, qui sunt in imo et
 dirigunt scalaria, erunt numero VII; reliqui quinque
 scaenae designabunt compositionem: et unus medius
 contra se valvas regias habere debet, et qui erunt
 dextra sinistra, hospitaliorum designabunt composi-
 tionem, extremi duo spectabunt itinera versurarum.
 Gradus spectaculorum, ubi subsellia componantur,
 gradus ne minus alti sint palmopede, <ne plus pedem>²
 et digito sex; latitudines eorum ne plus pedes duo
 4 semis, ne minus pedes duo constituentur. Tectum
 porticus, quod futurum est in summa gradatione
 cum scaenae altitudine libratum perspiciatur, ideo
 quod vox crescens aequaliter ad summas gradationes
 et tectum perveniet. Namque si non erit aequale,
 quo minus fuerit altum, vox praeripietur ad eam
 5 altitudinem, quam perveniet primo. Orchestra inter
 gradus³ imos quod diametron habuerit, eius sexta
 pars sumatur⁴, et in cornibus, utrumque aditus eius
 mensurae perpendicularum interiores sedes praeci-
 dantur, et quae praecisio fuerit, ibi constituentur
 itinerum supercilia; ita enim satis altitudinem
 6 habebunt eorum conformationes. Scaenae longi-
 tudo ad orchestrae diametron duplex⁵ fieri debet.
 Podii altitudo ab libramento pulpiti cum corona et
 lysi duodecumam orchestrae diametri. Supra podium

¹ circinationis *G*: -nes *H*. ² *add. Joc.*
³ gradus *G*. ⁴ summatur *H*. ⁵ dupl& *H*.

¹ Lit. "sighted."

triangles which run round the curve of the circle indicate the ascents and the steps between the blocks to the first circular passage. Above, the upper blocks of seats are arranged with alternate staircases facing the middle of the lower blocks. 3. The angles which are on the ground floor of the theatre and determine the staircases will be 7 in number. The remaining 5 will indicate the arrangement of the stage. One in the middle should have the palace doors opposite to it. Those which are to the right and left, will indicate the apartments provided for strangers. The furthest two will regard the direction of the revolving scenes. As to the rows of the auditorium where the seats are placed, the seats are not to be lower than 16 inches nor more than 18. The width is not to be more than $2\frac{1}{2}$ feet nor less than 2 feet. 4. The roof of the colonnade, which is to be built on the top row of steps, is to be so planned¹ as to be level with the top of the back wall of the stage, because thereby the voice will rise evenly until it reaches the top seats and the roof. For if the roof is not level, the lower it is, to that extent the voice will be interrupted, at the height which it reaches first. 5. As to the orchestra, a sixth part is to be taken of its diameter between the lowest steps. On the wings at either side of the entrance, the inmost seats are to be cut back to a perpendicular height equal to that sixth. Whatever the amount of this cutting off is, fixes the spring of the arch over the passages. In this way their vaulting will have sufficient height. 6. The length of the stage must be twice the width of the orchestra. The height of the pedestal of the back wall above the level of the stage, along with the cornice and moulding, is to be one twelfth of the diameter of the orchestra.

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columnae cum capitulis et spiris altae quarta parte eiusdem diametri; epistylia et ornamenta earum columnarum altitudinis quinta parte. Pluteum insuper cum unda et corona inferioris plutei dimidia parte. Supra id pluteum columnae quarta parte minore altitudine sint quam inferiores; epistylum et ornamenta earum columnarum quinta parte. Item si tertia episcenos futura erit, mediani plutei summum sit dimidia parte; columnae summae medianarum¹ minus altae sint quarta parte; epistylia cum coronis earum columnarum item habeant altitudinis quintam partem.

- 7 Nec tamen in omnibus theatris symmetriae ad omnis rationes et effectus possunt respondere, sed oportet² architectum animadvertere, quibus proportionibus necesse sit sequi symmetriam et quibus ad loci naturam aut magnitudinem operis temperari. Sunt enim res quas et in pusillo et in magno theatro necesse est eadem magnitudine fieri propter usum, uti gradus, diazomata, pluteos, itinera, ascensus, pulpita, tribunalia et si qua alia intercurrent, ex quibus necessitas cogit discedere ab symmetria, ne impediatur usus. Non minus si qua exiguitas copiarum, id est marmoris, materiae reliquarumque rerum, quae parantur in opere defuerint, paulum demere aut adicere, dum id ne nimium inprobe fiat sed cum sensu, non erit alienum. Hoc autem erit, si architectus erit usu peritus, praeterea ingenio mobili sollertiaque non fuerit viduatus.

¹ columnae summae medianarum *rec*: columnae summae media parte columnae summae medianarum *H*.

² oportere *H G*.

¹ *Tribunalia*: for magistrates.

BOOK V. c. vi.

Above the pedestal, the columns with capitals and bases are to be of a height equal to one quarter of the diameter; the architrave and ornaments, one fifth part of their height. The parapet above, with its base and cornice, is to be one half of the lower parapet (or pedestal). Above the parapet are to be columns one fourth less in height than the lower ones; the architrave and ornaments a fifth of those columns. If there is to be a third order, the top parapet is to be half of the middle one. The top columns are to be one quarter less in height than the middle; the architraves with the cornices are also to have one fifth of the height of those columns.

7. Nevertheless it is not in all theatres that the dimensions can answer to all the effects proposed. The architect must observe in what proportions symmetry must be followed, and how it must be adjusted to the nature of the site or the magnitude of the work. For there are details which must be of the same dimensions both in a small, and in a large theatre, since their use is the same. Such are the steps, the semi-circular passages, the parapets, the ordinary passages, the steps up, the height of the stage, the boxes¹; and whatever else occurs to compel us to depart from proportion in the interest of convenience. Similarly if scantness² of materials, such as marble, timber and other supplies, meet us in the work, it will not be inappropriate to make slight additions or deductions, provided this is done with taste and so as to avoid a clumsy effect. Such will be the result, if the architect in addition to being experienced, is not devoid of a versatile mind and technical skill.

² *Exiguitas*, by anacoluthon, lacks its verb: its equivalent *defuerint* supplies *fuerit*.

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- 8 Ipsae autem scaenae suas habent rationes explicitas ita, uti mediae valvae ornatus habeant aulae regiae, dextra ac sinistra hospitalia, secundum autem spatia ad ornatus comparata, quae loca Graeci *periactus* dicunt ab eo, quod machinae sunt in his locis versatiles trigonos habentes in singula tres species ornationis, quae, cum aut fabularum mutationes sunt futurae seu deorum adventus, cum tonitribus repentinis ea versentur mutantque speciem ornationis in frontes. Secundum ea loca versurae sunt procurrentes, quae efficiunt una a foro, altera a peregre
- 9 aditus in scaenam. Genera autem sunt scaenarum tria: unum quod dicitur tragicum, alterum comicum, tertium satyricum. Horum autem ornatus sunt inter se dissimili disparique ratione, quod tragicae deformantur columnis et fastigiis et signis reliquisque regalibus rebus; comicae autem aedificiorum privatorum et maenianorum¹ habent speciem profectusque² fenestris dispositos imitatione communium aedificiorum rationibus; satyricae vero ornantur arboribus, speluncis, montibus reliquisque agrestibus rebus in topeodi³ speciem deformati.

VII

- 1 IN Graecorum theatris non omnia isdem rationibus sunt facienda, quod primum in ima circinatione, ut in latino trigonorum IIII, in eo quadratorum trium

¹ moenianorum *H.*

² prospectus *ed. Ven.*: profectus *H.*

³ *cf. topia Book VII. v. 2.*

¹ The *periaktos* on the spectator's right represented the locality of the action: on the left, foreign parts.

BOOK V. c. VI.—C. VII.

8. The scenery itself is so arranged that the middle doors are figured like a royal palace, the doors on the right and left are for strangers. Next on either side are the spaces prepared for scenery. These are called *periaktoi* in Greek (revolving wings) from the three-sided machines which turn having on their three sides as many kinds of subject. When there are to be changes in the play or when the gods appear with sudden thunders, they are to turn and change the kind of subject presented to the audience. Next to these the angles of the walls run out which contain the entrances to the stage one from the public square ¹ and the other from the country. 9. There are three styles of scenery: one which is called tragic; a second, comic; the third, satyric. Now the subjects of these differ severally one from another. The tragic are designed with columns, pediments and statues and other royal surroundings; the comic have the appearance of private buildings and balconies and projections with windows made to imitate reality, after the fashion of ordinary buildings; the satyric settings are painted with trees, caves, mountains and other country features, designed to imitate landscape.

CHAPTER VII

ON GREEK THEATRES

1. IN the Greek theatres ² some things are done differently. Firstly, in the orchestra, the angles of three squares touch the circumference, whereas in the Roman theatre we have the angles of four

² Louis Dyer "Vitruvius' account of the Greek stage," *J.H.S.* XII. 356 ff.

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anguli circinationis lineam tangunt, et cuius quadrati
 latus est proximum scaenae praeciditque curvaturam ¹
 circinationis, ea regione designatur finitio proscaenii.
 Et ab ea regione ad extremam circinationem cur-
 vaturae parallelus linea designatur, in qua consti-
 tuitur frons scaenae, per centrumque orchestrae
 proscaenii regione parallelus ² linea describitur, et
 qua ³ secat circinationis lineas dextra ac sinistra, in
 cornibus hemicycli centra signantur. Et circino
 collocato in dextra ab intervallo sinistro circumagatur
 circinatio ad proscaenii sinistram ⁴ partem; item
 centro conlocato in sinistro cornu ab intervallo
 dextro circumagitur ad proscaenii dextram partem. ⁵
² Ita tribus centris hac descriptione ampliorem habent ⁶
 orchestram Graeci et scaenam recessiorem minoreque
 latitudine pulpitum, quod *logeion* ⁷ appellant, ideo
 quod <apud> ⁸ eos tragici et comici actores in scaena
 peragunt, reliqui autem artifices suas per orchestram
 praestant actiones; itaque ex eo scaenici et thyme-
 lici graece separatim nominantur. Eius loci altitudo
 non minus debet esse pedum x, non plus duodecim.
 Gradationes scalarum inter cuneos et sedes contra
 quadratorum angulos dirigantur ad primam prae-
 cinctionem, a praecinctione inter eas iterum mediae
 dirigantur, et ad summam quotiens praecinguntur,
 altero tanto semper amplificantur.

¹ curvatura *H.*

² per allelos *H.*

³ qua *Phil.*: quae *H.*

⁴ sinistram *Mar.*: dextram *H.*

⁵ item centro . . . dextram partem *post* ampliorem habent
H.: *transp. Joc.*

⁶ restituit *Joc.*

⁷ *λογεῖον* *Joc.*: *longion H.*

⁸ *add. rec.*

BOOK V. .C. VII.

triangles. In the Greek the line of the proscenium (or stage) is drawn along the side of the square which is nearest to the scenery, where it cuts the circumference. On the same side, parallel to this a line is drawn to touch the outside of the circle, and on this the front of the scenery is marked out. Through the centre of the orchestra a line is described parallel to the proscenium; where it cuts the circumference right and left, centres are marked at the ends of the semi-circle. Fixing the centre of the compasses on the right, with a radius equal to the distance of the left point, a circle is drawn to the left side of the proscenium. In the same way, the centre is fixed on the left and with a radius equal to the distance of the right, a circle is drawn to intersect the right side of the proscenium. 2. Thus the Greeks have a wider orchestra, drawn from these three centres. The scenery is more recessed. The stage is narrower: this they call *logeion* (speaking-place), for the reason that the tragic and comic actors deliver their speeches on the stage. The other artists carry on their action in the orchestra. Hence the Greek gives them separate names: stage players and chorus (*scaenici* et *thymelici*). The height of the stage is not to be less than ten feet, nor more than twelve. The staircases between the lowest blocks of seats are to be arranged opposite the several angles of the squares up to the first horizontal gangway; between the tops of the first staircases, higher flights are to be put at halfway intervals along the gangway. And generally speaking, they are to be doubled in number when a gangway is reached.

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VIII

- 1 Cum haec omnia summa cura sollertiaque explicata sunt, tunc etiam diligentius. Est enim advertendum, uti sit electus¹ locus, in quo leniter adplicet se vox neque repulsa resiliens incertas auribus referat significationes. Sunt enim nonnulli loci naturaliter impediens vocis motus, uti dissonantes, qui graece dicuntur *catechountes*,² circumsonantes, qui apud eos nominantur *periechountes*,³ item resonantes, qui dicuntur *antechountes*,⁴ consonantesque, quos appellant *synechountas*.⁵ Dissonantes sunt, in quibus vox prima, cum est elata in altitudinem, offensa superioribus solidis corporibus repulsaque residens in imo
- 2 opprimit insequentis vocis elationem; circumsonantes autem, in quibus circumvagando coacta exsolvens in medio sine extremis casibus sonans ibi extinguatur incerta verborum significatione; resonantes vero, in quibus, cum in solido tactu percussa resiliant, imagines exprimendo novissimos casus duplices faciant auditu; item consonantes sunt, in quibus ab imis auxiliata cum incremento scandens egrediatur ad aures disserta⁶ verborum claritate. Ita si in locorum electione fuerit diligens animadversio, emendatus erit prudentia ad utilitatem in theatris vocis effectus. Formarum autem descriptiones inter se discriminibus his erunt notatae, uti, quae⁷ ex quadratis designentur, Graecorum habeant usus,

¹ uti sit electus *Joc* : utiselectos *H*.

² catichontes *H*.

³ periechontes *H*.

⁴ antechontas *H*.

⁵ synechontas *H*.

⁶ disserta *H*.

⁷ ut quae *Joc* : itaque *H*.

BOOK V. c. VIII.

CHAPTER VIII

ON ACOUSTICS

1. Now that all these matters are set forth with careful skill, diligent consideration must be given. For we must choose a site in which the voice may fall smoothly, and may reach the ear with a definite utterance and without the interference of echoes. For there are some places which naturally hinder the passage of the voice: the dissonant which the Greek call *katechountes*; the circumsonant which are named by them *periechountes*; the resonant also which are called *antechountes*; the consonant which they name *synechountes*. The dissonant places are those in which the voice, when first it rises upwards, meets solid bodies above. It is driven back, and settling down, overwhelms the following utterance as it rises.

2. The circumsonant are those in which the voice moves round, is collected and dissipated in the centre. The terminations of the words are lost and the voice is swallowed up in a confused utterance. The resonant are those in which the words, striking against a solid body, give rise to echoes and make the termination of the words double to the ear. The consonant also are those in which the voice reinforced from the ground rises with greater fulness, and reaches the ear with clear and eloquent accents. Thus if careful observation is exercised in the choice of sites, such skill will be rewarded by the improved effect of the actors' voices. To sum up, the outlines of the plans will be marked by these differences among themselves, namely, those plans follow Greek usage which are designed from squares; the Roman

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latine paribus¹ lateribus trigonorum. Ita his praescriptionibus qui voluerit uti, emendatas efficiet theatrorum perfectiones.

IX

- 1 Post scaenam porticus sunt constituendae, uti, cum imbres repentini ludos interpellaverint, habeat populus, quo se recipiat ex theatro, choragiaeque laxamentum habeant ad comparandum. Uti sunt porticus Pompeianae, itemque Athenis porticus Eumeniae Patrisque Liberi fanum et exeuntibus e theatro sinistra parte odeum, quod Themistocles columnis lapideis dispositis navium malis et antemnis e spoliis Persicis pertexit (idem autem etiam incensum Mithridatico bello rex Ariobarzanes restituit); Smyrnae Stratoniceum; Tralibus² porticus ex utraque parte, ut³ scaenae, supra stadium; ceterisque civitatibus, quae diligentiores habuerunt architectos,
- 2 circa theatra sunt porticus et ambulationes. Quae videntur ita oportere conlocari, uti duplices sint habeantque exteriores columnas doricas cum epis-

¹ paribus *Joc*: raribus *H*.

² Tralibus *ed*: trabibus *H*. ³ est *Kr*: ut *H*.

¹ Lit. "in the Roman manner," cf. *ionice*, Book VII. *pref.* 12.

² *χορηγία* Arist. *Poet.* 14. 2.

³ No remains above ground. The statue of Pompey of the Palazzo Spada found near.

⁴ Eumenes II. of Pergamus. The colonnades connected the Theatre with the Odeum.

⁵ The temple of Dionysus Eleuthereus adjoined the theatre, Paus. I. 20.

⁶ The present Odeum was built about 160 A.D.

BOOK V. c. VIII.—c. IX.

theatres,¹ from equilateral triangles. Whoever uses these rules, will be successful in building theatres.

CHAPTER IX

ON COLONNADES AND PASSAGES BEHIND THE SCENES

1. BEHIND the stage, colonnades are to be planned so that when the play is interrupted by sudden showers, the audience may have a place of refuge; the colonnades may also furnish room to set up the stage machinery.² At Rome there are the Colonnades of Pompey³; at Athens there are the Colonnades of Eumenes,⁴ the Temple of Bacchus,⁵ and as you leave the theatre, on the left-hand side there is the Odeum.⁶ This⁷ Themistocles planned with stone columns and completed with masts and yards from the Persian spoils. It was burnt in the Mithridatic War⁸ and King Ariobarzanes⁹ restored it. At Smyrna is the Colonnade of Stratonice.¹⁰ At Tralles there are colonnades above the stadium on either side, like those of a theatre. In other cities also which have had skilful architects there are colonnades and walks adjoining the theatres. 2. These, it appears, should be so planned that they are double,¹¹ having Doric columns on the outside finished with

⁷ Completed by Pericles. Plut. *vit.* 13.

⁸ Athens taken by Sulla B.C. 86.

⁹ Ariobarzanes Philopator, king of Cappadocia c. 60 B.C., entrusted the work to Roman architects, C. and M. Stallius, cf. Wilms. 1941. *I.G.* III. 541.

¹⁰ Tac. *Ann.* III. 63.

¹¹ As in Colonnade of Octavius, Plin. *N.H.* XXXIV. 13; Platner 426. This had Corinthian capitals.

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tyliis et ornamentis ex ratione modulationis¹ perfectas. Latitudines autem earum ita oportere fieri videntur, uti, quanta altitudo columnae fuerit exteriores, tantam latitudinem habeant ab inferiore parte columnarum extremarum ad medias et a medianis ad parietes qui circumcludunt porticus ambulationes. Medianae autem columnae quinta parte altiores sint quam exteriores, sed aut ionico³ aut corinthio genere deformentur. Columnarum autem proportionibus et symmetriis non erunt isdem rationibus quibus in aedibus sacris scripsi; aliam enim in deorum templis debent habere gravitatem, aliam in porticibus et ceteris operibus subtilitatem. Itaque si dorici generis erunt columnae, dimetiantur² earum altitudines cum capitulis in partes xv. Ex eis partibus una constituatur et fiat modulus, ad cuius moduli rationem omnis operis erit explicatio. Et in imo³ columnae crassitudo fiat duorum modulorum; intercolumnium quinque et moduli dimidia parte; altitudo columnae praeter capitulum xiiii modulorum; capituli altitudo moduli unius, latitudo modulorum duorum et moduli sextae partis. Ceteri operis modulationes, uti in aedibus sacris in libro iiii⁴ scriptum est, ita perficiantur. Sin autem ionicae columnae fient, scapus⁴ praeter spiram et capitulum in octo et dimidiam partem dividatur, et ex his una⁵ crassitudini columnae detur; <spira>⁶ cum plintho dimidia crassitudine constituatur⁷; capituli ratio ita fiat, uti in libro tertio est demonstratum. Si corinthia erit, scapus et spira uti in ionica; capitulum autem, quemadmodum in quarto libro est scriptum, ita

¹ modulationes *H.*

² demetiantur *H.*

³ in imo *Joc*: in primo *H.*

⁴ scaphus *H.*

⁵ una *G*: *om.* *H.*

⁶ *add.* *Joc.*

BOOK V. c. ix.

architraves and ornaments in due proportion. The width of the colonnades should be arranged as follows. Taking the height of the outer columns, this will give the width from the lower part of the outer columns to the middle columns and from the middle columns to the walls which surround the walks of the colonnades. The middle columns are to be designed one fifth higher than the outer ones, and either in the Ionic or Corinthian style. 3. The proportions and symmetries of the columns will not be calculated in the same way as I have described for sacred edifices. In the temples of the gods dignity should be aimed at; in colonnades and other similar works, elegance. And so if the columns are in the Doric style, their height including the capitals is to be divided into 15 parts of which one is to be the module. The planning of the whole work is to be calculated to this module. The thickness of the column at the foot is to be of two modules. The intercolumniation is to be $5\frac{1}{2}$ modules. The height of the column excluding the capital is to be 14 modules. The height of the capital is to be one module; the width $2\frac{1}{6}$ modules. The proportions of the rest of the work are to be completed as laid down in the fourth book for sacred edifices. 4. But if the columns are Ionic, the shaft apart from the base and capital is to be divided into $8\frac{1}{2}$ parts and of these one is to be given to the diameter of the column. The base, with the plinth, is to be of half the diameter. The capital is to be designed as set forth in the third book. If the column is Corinthian, the shaft and base are to be as in the Ionic, but the capital is to be proportioned as

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habeant rationem. Stylobatisque adiectio quae fit per scabillos¹ inpares,² ex descriptione, quae supra scripta est in libro tertio, sumatur. Epistylia, coronae ceteraque omnia ad columnarum rationem ex scriptis voluminum superiorum explicantur.

- 5 Media vero spatia quae erunt subdiu inter porticus, adornanda viridibus videntur, quod hypaethroe ambulationes habent magnam salubritatem. Et primum oculorum, quod ex viridibus subtilis³ et extenuatus aer propter motionem corporis influens perlimat speciem et ita auferens ex oculis umorem crassum, aciem tenuem et acutam speciem relinquit⁴; praeterea, cum corpus motionibus in ambulatione calescat, umores ex membris aer exsugendo inminuit plenitates extenuatque⁵ dissipando quod plus inest
- 6 quam corpus potest sustinere. Hoc autem ita esse ex eo licet animadvertere, quod, sub tectis cum sint aquarum fontes aut etiam sub terra palustris abundantia, ex his nullus surgit umor nebulosus, sed in apertis hypaethrisque locis, cum sol oriens vapore tangat mundum, ex umidis et abundantius excitat umores et exconglobatos in altitudinem tollit. Ergo si ita videtur, uti in hypaethris locis ab aere umores ex corporibus exsugantur molestiores, quemadmodum ex terra per nebulas videntur, non puto dubium esse, quin amplissimas et ornatissimas subdiu hypaethrisque⁶ conlocari oporteat in civitatibus ambulationibus.
- 7 Eae autem uti sint semper siccae et non

¹ scabillos *H*: scabillum *Am. Ps.* 98. 5.

² inpares *Joc*: inpartes *H*. ³ subtilis *G*: subtiles *H*.

⁴ relinquit *G*: -quid *H*. ⁵ extenuatque *H*.

⁶ hypetrisque *H*.

¹ The Romans suffered severely from inflamed eyes. There were eye-doctors, *ocularii*.

BOOK V. c. ix.

set forth in the fourth book. The addition to the stylobates is to be made by unequal ordinates in accordance with the description which is given above in the third book. The architraves, cornices and other features are to be arranged to suit the columns in accordance with the previous books.

5. The open spaces which are between the colonnades under the open sky, are to be arranged with green plots; because walks in the open are very healthy, first for the eyes,¹ because from the green plantations,² the air being subtle and rarefied, flows into the body as it moves, clears the vision, and so by removing the thick humour from the eyes, leaves the glance defined and the image clearly marked. Moreover, since in walking the body is heated by motion, the air extracts the humours from the limbs, and diminishes repletion, by dissipating what the body has, more than it can carry. 6. We can perceive that this is so from the fact that when springs of water are under cover, or there is underground a marshy flow, no moist vapour rises. In places open to the air and sky, when the rising sun touches the world with its warmth, it draws the moisture from moist sites even more abundantly, gathers it together and raises it above. Therefore if it appears that in open places the more troublesome moisture is sucked out from the body, as it is seen to be drawn from the earth through the clouds, I do not think it is doubtful but that in cities extensive and ornate parades should be placed in the open, and exposed to the sun. 7. In order that these walks may be

² Gardens depended rather upon shrubs and trees than upon flowers for effect; in this, resembling modern Italian gardens.

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lutosae, sic erit faciendum. Fodiantur et exinaniantur quam altissime. Dextra atque sinistra structiles cloacae fiant, inque earum parietibus qui ad ambulationem spectaverint, tubuli instruantur inclinati fastigio. In cloacis his perfectis compleantur ea loca carbonibus, deinde insuper sabulone eae ambulationes sternantur et exaequantur. Ita propter carbonum raritatem naturalem et tubulorum in cloacas instructionem excipientur aquarum abundantiae, et ita siccae et sine umore perfectae fuerint ambulationes.

- 8 Praeterea in his operibus thesauri sunt civitatibus in necessariis rebus a moribus constituti. In conclusionibus enim reliqui omnes faciliores sunt apparatus quam lignorum. Sal enim facile ante inportatur, frumenta publice privatimque expeditius congeruntur, et si deficit, holeribus, carne seu leguminibus defenditur, aquae fossuris puteorum et de caelo repentinis tempestatibus ex tegulis excipiuntur. De lignatione quae maxime necessaria est ad cibum quoquendum,¹ difficilis et molesta est apparatus, quod
9 et tarde conportatur et plus consumitur. In eiusmodi temporibus tunc eae ambulationes aperiuntur et mensurae tributim singulis capitibus designantur. Ita duas res egregias hypaethra² ambulationem³ praestant, unam in pace salubritatis, alteram in bello salutis. Ergo his rationibus ambulationum explicationes non solum post scaenam theatri, sed etiam omnium deorum templis effectae magnas civitatibus praestare poterunt utilitates.

¹ quoquendum *H.* ² hypaethrae *Ro* : hypetra *H.*

³ ambulationes *ed* : -nem *H.*

¹ a moribus *H* = ἔθει.

BOOK V. c. ix.

always dry and free from mud, the following measures should be taken. They are to be dug and emptied out as deeply as possible. Drains are to be constructed right and left. In the walls of these, which are on the side of the parade, pipes are to be fixed inclined to the drains. When this is complete, the place is to be filled with charcoal; then above this the walks are to be covered with sand and levelled. Thus by the natural porosity of the charcoal, and by the insertion of the pipes, the overflow of the water will be taken off. Thus the parades will be dry and without moisture.

8. Moreover in these buildings, custom¹ included depots for stores required by the cities. In times of siege,² the provision of everything else is more easy than that of wood. Salt is easily brought in beforehand. Corn is quickly gathered by the community and by individuals. If it fails, provision can be made with green vegetables, meat or beans. Water is obtained by the digging of wells; in sudden storms it is received from the sky by the roof tiles. But the provision of fire-wood, which is most necessary for cooking food, is difficult and troublesome. For it takes time to collect and is used in large quantities.

9. In times of siege the walks are thrown open, and wood is distributed to each citizen according to his tribe. Thus walks in the open air serve two outstanding purposes: health in time of peace, and security in war. In this way the laying out of walks, not only behind the stage of the theatre but also for the temples of all the gods, can furnish cities with great advantages.

² Vitruvius may have in view the famous siege of Marseilles, 49 B.C.

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Quoniam haec nobis satis videntur esse exposita, nunc insequentur balinearum dispositionum demonstrationes.

X

- 1 PRIMUM eligendus locus est quam calidissimus, id est aversus ab septemtrione et aquilone. Ipsa autem caldaria tepidariaque lumen habeant ab occidente hiberno, si autem natura loci impedierit, utique a meridie, quod maxime tempus lavandi a meridiano ad vesperum est constitutum. Et item est animadvertendum, uti caldaria¹ muliebria et virilia coniuncta et in isdem regionibus sint conlocata; sic enim efficietur, ut in vasaria et hypocaustis communis sit eorum utrisque. Aenea supra hypocaustum tria sunt componenda, unum caldarium, alterum tepidarium, tertium frigidarium, et ita conlocanda, uti, ex tepidario in caldarium quantum aquae caldae exierit, influat de frigidario in tepidarium ad eundem modum, testudinesque alveolorum ex communi
- 2 hypocausti calfaciantur. Suspensurae caldariorum ita sunt faciendae, ut primum sesquipedalibus tegulis solum sternatur inclinatum ad hypocaustum, uti pila cum mittatur, non possit intro resistere, sed rursus redeat ad praefurnium ipsa per se; ita flamma facilius pervagabitur sub suspensione. Supraque

¹ calcaria *H.*

¹ Plate *H.*

² Gymnastic exercises were taken immediately before or after the bath.

³ These rules are followed in the Stabian Baths at Pompeii, Plate *H.*

BOOK V. c. ix.-c. x.

Since these topics seem to us to be enough explained, there will now follow a description of the planning of baths.¹

CHAPTER X

ON BATHS

1. **FIRSTLY** a site must be chosen as warm as possible, that is, turned away from the north and east. Now the hot and tepid baths are to be lighted from the winter west; but if the nature of the site prevents, at any rate from the south. For the time of bathing² is fixed between midday and evening: We must also take care that the hot baths for men and for women are adjacent and planned with the same aspects. For in this way it will follow that the same furnace and heating system will serve for both baths and for their fittings. Three bronze tanks are to be placed above the furnace: one for the hot bath, a second for the tepid bath, a third for the cold bath.³ They are to be so arranged that the hot water which flows from the tepid bath into the hot bath, may be replaced by a like amount of water flowing down from the cold into the tepid bath. The vaulted chambers which contain the basins, are to be heated from the common furnace. 2. The hanging floors⁴ of the hot baths are to be made as follows: first the ground is to be paved with eighteen inch tiles sloping towards the furnace, so that when a ball is thrown in it does not rest within, but comes back to the furnace room of itself. Thus the flame will more easily spread under the floor. On this pavement, piers of

⁴ This system of heating is said to have been invented by L. Sergius Orata c. 100 B.C. Plin. *N.H.* IX. 168.

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laterculis besalibus pilae struantur ita dispositae, uti bipedales tegulae possint supra esse conlocatae; altitudinem autem pilae habeant pedes duo. Eaeque struantur argilla cum capillo subacta, supraque conlocentur tegulae bipedales quae sustineant pavimentum. ³ Concamarationes vero si ex structura factae fuerint, erunt utiliores; sin autem contignationes fuerint, figlinum opus subiciatur. Sed hoc ita erit faciendum. Regulae¹ ferreae aut arcus fiant, eaeque uncinis ferreis ad contignationem suspendantur quam creberrimis; eaeque regulae sive arcus ita disponantur, uti tegulae sine marginibus sedere in duabus invehique possint, et ita totae concamarationes in ferro nitentes sint perfectae. Earumque camararum superiora coagmenta ex argilla cum capillo subacta liniantur; inferior² autem pars, quae ad pavimentum spectat, primum testa cum calce trullizetur,³ deinde opere albario sive tectorio poliatur. Eaeque camerae in caldariis si duplices factae fuerint, meliorem habebunt usum; non enim a vapore umor corrumpere poterit materiem contignationis, sed inter duas camaras vagabitur. ⁴ Magnitudines autem balneorum videntur fieri pro copia hominum; sint ita compositae. Quanta longitudo fuerit tertia dempta, latitudo sit, praeter scholam⁴ labri et alvei. Labrum utique sub lumine faciundum videtur, ne stantes⁵ circum suis umbris obscurant lucem. Scholas autem laborum ita

¹ regula *H.*

² inferior *Fav*: interior *H.*

³ trullizetur *G*: tulizetur *H.*

⁴ scolam *H.*

BOOK V. c. x.

eight inch bricks are to be built at such intervals that two foot tiles can be placed above. The piers are to be two feet high. They are to be laid in clay worked up with hair, and upon them two foot tiles are to be placed to take the pavement. 3. The vaulted ceilings will be more convenient if they are made of concrete. But if they are of timber, they should be tiled underneath, in the following fashion. Iron bars or arches are to be made and hung on the timber close together with iron hooks. And these rods or arches are to be placed so far apart that the tiles without raised edges may rest upon, and be carried by them; thus the whole vaulting is finished resting upon iron. Of these vaulted ceilings the upper joints are to be stopped with clay and hair kneaded together. The under side, which looks to the pavement below, is to be first plastered with potsherds and lime pounded together, and then finished with stucco¹ or fine plaster. Such vaulting over hot baths will be more convenient if it is made double. For the moisture from the heat cannot attack the wood of the timbering but will be dispersed between the two vaults. 4. Now the size of the baths is to be proportioned to the number of persons, and is to be thus arranged. Apart from the apse containing the bathing tub and the basin in which it stands, the breadth is to be two thirds of the length. The bathing tub should be placed under the light so that the bystanders do not obscure the light with their shadows. The apses for the

¹ The worker in stucco, *albarius tector*, could not only work up a smooth surface for fresco painting, *opus tectorium*, but moulded raised ornaments and figures. Tert. *Idol.* 8.

⁵ *circumstantes e₂ Joc.*

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fuerit oportet spatiosas, uti, cum priores occupaverint loca circum, spectantes reliqui recte stare possint. Alvei autem latitudo inter parietem et pluteum ne minus sit pedes senos, ut gradus inferior inde auferat
5 et pulvinus duos pedes. Laconicum sudationesque sunt coniungendae tepidario; eaeque quam latae fuerint, tantam altitudinem habeant ad imam curvaturam hemisphaerii.¹ Mediumque lumen in hemisphaerio² relinquatur, ex eoque clypeom aeneum catenis pendeat, per cuius reductiones et dimissiones perficietur sudationis temperatura. Ipsumque ad circinum fieri oportere videtur, ut aequaliter a medio flammae vaporisque vis per curvaturae rutundationes pervagetur.

XI

- 1 NUNC mihi videtur, tametsi³ non sint italicae consuetudinis palastrarum aedificationes,⁴ traditae tamen, explicare et quemadmodum apud Graecos constituentur, monstrare.⁵ In palaestris peristylia quadrata sive oblonga ita sint facienda, uti duorum stadiorum habeant ambulationis circuitum, quod Graeci vocant *diaulon*,⁶ ex quibus tres porticus simplices disponantur, quarta quae ad meridianas regiones est conversa, duplex, uti, cum tempestates

¹ hemisperii *H*.

² hemisperio *H*.

³ tametsi *ed*: iam etsi *H*.

⁴ aedificationes *G*: -nis *H S*.

⁵ constituentur . . . disputare possint *ex hoc loco inseruit Galiani infra post pervenire*.

⁶ diaulam *H*.

¹ fuerit subj. dependent on *oportet*, which governs *scholas*.

² Yet there is a palaestra in the Stabian baths at Pompeii. Strictly, however, the palaestra (wrestling school) is part of the gymnasium, which latter is here described.

BOOK V. c. x.-c. xi.

bathing tubs should be¹ spacious so that when the first comers have taken their places, the others watching their turn may stand conveniently. Now the width of the basin between the wall and the parapet, should be not less than six feet, from which the lower step and the "cushion," are to take two feet. 5. The domed sweating chamber should adjoin the tepid bath. The height to the springing of the dome should be equal to the width. In the middle of the dome a light is to be left. From this a bronze tray is hung with chains; by the raising and lowering of the tray from the opening, the sweating is adjusted. The tray should be circular, so that the force of the flame and the heat may be diffused equally from the centre over the rounded curve.

CHAPTER XI

ON THE PALAESTRA

1. ALTHOUGH the building of the palaestra is not a usual thing in Italy,² the method of construction has been handed down. It seems good therefore to explain it and show how the palaestra is planned among the Greeks. Square or oblong cloisters³ are to be made⁴ with a walk round them of two furlongs (this walk the Greeks call *diaulos*). Three of the sides are to be single colonnades; the fourth which has a south aspect is to be double, so that when rain

³ Or peristyles. Herod's Temple at Jerusalem was surrounded by a double colonnade of white marble columns except on the south which was quadruple and two stories high. The eastern colonnade was called Solomon's Porch.

⁴ *sint facienda*, a duplicated jussive.

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ventosae sint, non possit aspergo in interiorem partem
 2 pervenire. Constituantur autem in tribus porticibus
 exhedrae¹ spatiosae, habentes sedes, in quibus
 philosophi, rhetores reliquique, qui studiis delectantur,
 sedentes disputare possint. In duplici autem porticu
 conlocentur haec membra: ephebeum in medio (hoc autem
 est exhedra amplissima cum sedibus) tertia parte longior
 sit quam lata; sub dextro coryceum, deinde proxime
 conisterium, a conisterio in versura porticus frigida
 lavatio, quam Graeci *loutron*² vocitant; ad sinistram
 ephebei elaeothesium, proxime autem elaeothesium
 frigidarium, ab eoque iter in propnigeum in versura
 porticus. Proxime autem introrsus e regione frigidarii
 conlocetur concamerata sudatio longitudine duplex
 quam latitudo, quae habeat in versuris ex una parte
 laconicum ad eundem modum, uti quam supra scriptum
 est, compositum, ex adverso laconici caldam lavationem.
 In palaestra peristylia,³ quemadmodum supra scriptum
 est, ita debent esse
 3 perfecta distributa. Extra autem disponantur porticus
 tres, una ex peristylo exeuntibus, duae dextra
 atque sinistra stadiatae, ex quibus una quae spectaverit
 ad septentrionem, perficiatur duplex amplissima
 latitudine, altera simplex, ita facta, uti in partibus,
 quae fuerint circa parietes et quae erit ad columnas,
 margines habeant uti semitas non minus pedum
 denum mediumque excavatum, uti gradus sint in
 descensu marginibus sesquipedem ad planitiem,
 quae planities sit non minus pedes XII; ita

¹ exedrae H.

² lytron H.

³ peristylia H.

¹ Perfecta distributa H.

BOOK V. c. xi.

is accompanied by gales, the drops may not reach the inside. 2. On the other three sides, spacious *exhedrae* (apsidal recesses) are to be planned with seats where philosophers, teachers of rhetoric and other studious persons can sit and discuss. In the double colonnade, however, these provisions are to be made. In the centre there is to be the *ephebeum* (a large apsidal recess with seats for young men) a third longer than it is wide; on the right the *coryceum* (for exercise with the quintain); next to this the *conisterium* (for athletes to powder themselves); adjoining the conisterium at the angle of the colonnade the cold bath which the Greeks call *loutron*; at the left of the ephebeum, the *elaethesium* (for athletes to oil themselves); next to this is the cold room from which the furnace-room is entered at the angle of the colonnade. Adjoining this on the inside in line with the cold room, a vaulted sweating-room is to be placed, twice as long as it is broad, having in the angle of the colonnade the *Laconicum* (domed sweating room) constructed as before described (c. x 5), and opposite this a warm bath. In the palaestra, the cloisters ought to be thus completed and arranged.¹ 3. Outside the palaestra three colonnades are to be arranged; the first, as you go out of the peristyle; right and left of this, two colonnades with running tracks. Of these three the one which has a north aspect, is to be built double and very wide; the others are to be single. On the sides which adjoin the walls and those which adjoin the columns, they are to have borders ten feet wide to serve as paths. The middle part is to be excavated with steps down from the paths to the level track a foot and a half below, and the track is to be not less than 12 feet

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qui vestiti ambulaverint circum in marginibus, non
4 inpedientur ab unctis¹ se exercentibus. Haec autem
porticus *xystos* apud Graecos vocitatur, quod athletae
per hiberna tempora in tectis stadiis² exercentur.³
Proxime autem xystum et duplicem porticum
designentur hypaethroe⁴ ambulationes, quas Graeci
paradromidas, nostri xysta appellant, in quas per
hiemem ex xysto sereno caelo athletae prodeuntes
exercentur. Faciunda⁵ autem xysta sic videntur,
ut sint inter duas porticus silvae aut platanones,⁶ et
in his perficiantur inter arbores ambulationes ibique
ex opere signino stationes. Post xystum autem
stadium ita figuratum, ut possint hominum copiae
cum laxamento athletas⁷ certantes spectare. Quae
in moenibus necessaria videbantur esse, ut apte dis-
ponantur, perscripsi.

XII

1 DE opportunitate autem portuum non est praeter-
mittendum sed, quibus rationibus tueantur naves in his
ab tempestatibus, explicandum. Hi autem natural-
iter si sint bene positi habeantque acroteria sive pro-
munturia procurrentia, ex quibus introrsus curvaturae

¹ unctis *Salmasius* : cunctis *H.*

² stadiis *H.* : studiis *H^e G.*

³ *hinc postposuit Schn.* faciunda autem . . . stationes
post . . . prodeuntes exercentur.

⁴ hypaethroe *Ro* : hypetro eae *H G.*

⁵ faciunda . . . stationes *huc transposuit Galiani.*

⁶ platanones et *Joc* : platanon esset *H.*

⁷ athl&an *H.*

BOOK V. c. XI.—c. XII.

wide. Thus persons who walk about on the paths in their clothes will not be disturbed by the athletes who use oil. 4. Such a colonnade is called *xystos* by the Greeks, whose athletes take exercise in the winter on covered tracks. Next to the covered track and the double colonnade walks in the open are to be planned (which the Greeks call *paradromides* and our people *xysta*). When it is fine weather in winter, the athletes come into the open and take exercise here. The *xysta* ought to be so laid out that there are plantations or groves of plane trees between the two colonnades. Here walks are to be made among the trees with spaces paved with cement.¹ Behind the *xystum*, the *stadium* (sports ground) should be so planned that large crowds can comfortably see the competitors. I have now enumerated the buildings required within the city walls and their suitable disposition.

CHAPTER XII

ON HARBOURS AND SHIPYARDS

1. It remains to deal with the suitable arrangement of harbours,² and to explain by what means, in these, ships are protected from stormy weather. There are great advantages if they are well placed by nature and have headlands (*acroteria*) jutting out, behind which bays or creeks are formed owing to the nature of the place. For round these colonnades

¹ *Opus signinum* composed of lime, sand and pounded pottery, which set as hard as stone.

² Timoxenus wrote on harbours, Aesch. *Persae* 306 *schol.*

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sive versurae ex loci natura fuerint conformatae, maximas utilitates videntur habere. Circum enim porticus sive navalia¹ sunt facienda sive ex porticibus aditus <ad>² emporia, turresque ex utraque parte conlocandae, ex quibus catenae traduci per machinas possint.

- 2 Sin autem non naturalem locum neque idoneum ad tuendas ab tempestatibus naves habuerimus, ita videtur esse faciendum, uti, si nullum flumen in his locis impedierit sed erit ex una parte statio, tunc ex altera parte structuris sive aggeribus expediantur progressus, et ita conformandae portuum conclusiones. Eae³ autem structurae, quae in aqua sunt futurae, videntur sic esse faciendae, uti portetur pulvis a regionibus, quae sunt a Cumis continuatae ad promunturium Minervae, isque misceatur, uti in
- 3 mortario duo ad unum respondeant. Deinde tunc in eo loco, qui definitus erit, arcae stipitibus robusteis et catenis inclusae in aquam demittendae destinandaeque firmiter; deinde inter ea ex trastilis inferior pars sub aqua exaequanda et purganda, et caementis ex mortario materia mixta, quemadmodum supra scriptum est, ibi congerendum, donique⁴ conpleatur structurae spatium, quod fuerit inter arcas. Hoc autem munus naturale habent ea loca, quae supra scripta sunt.

Sin autem propter fluctus aut impetus aperti pelagi destinae arcae non potuerint continere, tunc ab ipsa terra sive crepidine pulvinus quam firmissime struatur, isque pulvinus exaequata struatur planitia

¹ sive navalia *rec* : sivenalia *H*.

² *add. Joc.*

³ eae *H* : hae *G*.

⁴ denique *H* : compleantur *H*.

¹ Used at Cyzicus A.D. 365. *Amm. XXVI. viii. 8.*

BOOK V. c. XII.

either docks are to be made, or approaches from the colonnades to the warehouses. On either side towers are to be built from which chains¹ (across the harbour) can be drawn by machinery.

2. But if we have no natural harbour suitable for protecting ships from a stormy sea, we must proceed as follows. If there is an anchorage on one side without any river mouth to interfere, piers are to be constructed on the other side by masonry or embankments in order to form an enclosed harbour. The masonry which is to be in the sea must be constructed in this way. Earth² is to be brought from the district which runs from Cumae to the promontory of Minerva,³ and mixed, in the mortar, two parts to one of lime. 3. Then in the place marked out, cofferdams,⁴ formed of oak piles and tied together with chains, are to be let down into the water and firmly fixed. Next, the lower part between them under the water is to be levelled and cleared with a platform of small beams laid across and the work is to be carried up with stones and mortar as above described, until the space for the structure between the dams is filled. Such is the natural advantage of the places described above.

But if on account of the breakers or the violence of the open sea, the supports cannot uphold the dams, then a platform is to be laid, as firmly as possible, starting from the edge of the shore or from a break-water. This platform is to be laid with a level top

² Pozzuolana is a brown volcanic ash which, mixed with lime, sets under water. A similar ash is also found near Rome.

³ Sorrento.

⁴ "The concrete was to be lowered into the sea in *caissons* to form the foundation of the piers." The mole at Puteoli was an example. Stuart Jones *Companion* 156.

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minus quam dimidiae partis, reliquum quod est
4 proxime litus, proclinatum latus habeat. Deinde ad ipsam aquam et latera pulvino circiter sesquipediales margines struantur aequilibrés ex planitia, quae est supra scripta; tunc proclinatio ea impleatur harena et exaequetur cum margine et planitia pulvini. Deinde insuper eam exaequationem pila quam magna constituta fuerit, ibi struatur; eaque, cum erit extructa, relinquatur ne minus duos mensis, ut siccescat. Tunc autem succidatur margo quae sustinet harenam; ita harena fluctibus subruta efficiet in mare pilae praecipitationem. Hac ratione, quotienscumque opus fuerit, in aquam poterit esse progressus.

5 In quibus autem locis pulvis non nascitur, his rationibus erit faciendum, uti arcae duplices relatis tabulis et catenis conligatae in eo loco, qui finitus erit, constituentur, et inter destinas creta in eronibus ex ulva palustri factis calcetur. Cum ita bene calcatum et quam densissime fuerit, tunc cocleis rotis tympanis conlocatis locus qui ea septione finitus fuerit, exinaniatur sicceturque, et ibi inter septiones fundamenta fodiantur. Si terrena erunt, usque ad solidum, crassiora quam qui murus supra futurus erit, exinaniatur sicceturque et tunc structura ex
6 caementis calce et harena compleatur. Sin autem mollis locus erit, palis ustilatis alneis aut oleagineis configantur et carbonibus compleantur, quemadmodum in theatrorum et muri foundationibus est scriptum. Deinde tunc quadrato saxo murus ducatur iuncturis quam longissimis, uti maxime medii lapides

¹ *Eronibus harenae plenis* Plin. N.H. XXXVI. 96.

² Book X. v and vi.

BOOK V. c. XII.

(towards the sea) less than half its width; towards the shore, it is to have a sloping side. 4. Then towards the water and on the side of the platform construct margins projecting about one and a half feet level with the top mentioned above. Then the overhanging part is to be filled up underneath with sand and made level with the margin and the surface of the platform. Next, a pillar of the size appointed is to be built upon the levelled surface, and when it is finished, it is to be left to set for two months. The margin which keeps up the sand is to be cut away: thus the sand is washed away by the waves and causes the pillar to fall into the sea. In this way, as often as it is necessary, the pier is carried further into the water.

5. Where, however, the earth in question is not found, we must proceed as follows. Double cofferdams bound together with planks and chains are to be put in the place marked out. Between the supports, clay in hampers¹ made of rushes is to be pressed down. When it is well pressed down and as closely as possible, the place marked out by the enclosure is to be emptied with waterscrews and waterwheels² with drums, and so dried. Here the foundations are to be dug. If the foundations are on the sea bottom, they are to be emptied and drained to a greater width than the wall to be built upon them, and then the work is to be filled in with concrete of stone lime and sand. 6. But if the bottom is soft the foundations are to be charred piles of alder and olive filled in with charcoal, as prescribed for the foundations of theatres and the city walls. The wall is then raised of squared stone with joints as long as possible, so that the middle stones may be

VITRUVIUS

coagmentis contineantur. Tunc, qui locus erit inter murum, ruderatione sive structura compleatur. Ita erit uti possit turris insuper aedificari.

- 7 His perfectis navaliorum ea erit ratio, ut constuantur spectantia maxime ad septentrionem; nam meridianae regiones propter aestus cariem, tineam, teredines reliquaque bestiarum nocentium genera procreant alendoque conservant. Eaque aedificia minime sunt materianda¹ propter incendia. De magnitudinibus autem finitio nulla debet esse, sed faciunda ad maximum navium modum, uti, etsi maiores naves subductae fuerint, habeant cum laxamento ibi conlocationem.

Quae necessaria ad utilitatem in civitatibus publicorum locorum succurrere mihi potuerunt,² quemadmodum constituentur et perficiantur, in hoc volumine scripsi; privatorum autem aedificiorum utilitates et eorum symmetrias insequenti volumine ratiocinabor.

¹ materianda *H*.

² potuerunt *G*: poterunt *H*.

BOOK V. c. XII.

well tied together by the jointing. The inside of the wall is then to be filled in with rubble or masonry. Thus it may be possible for a tower to be built upon it.

7. Subsequently the shipyards are to be built and with a northern aspect, as a rule. For southern aspects because of their warmth generate dry rot, wood worms and ship worms with other noxious creatures, and feed and maintain them. Further, such buildings should have very little wood in them because of fire. As to their dimensions no rule should be laid down. They are to be made to take the largest vessels; so that even if such vessels are drawn ashore, they may have a roomy berth.

In this book I have described how the works required for public purpose in cities are to be planned and carried out. The next book¹ will consider the requirements of private buildings and their due proportions.

¹ Vitruvius probably published his work at intervals; hence these cross-references throughout. Additions to the main body of the work seem to have been made on the publication of the several books: Book V. i. 8, 9 is an instance.

VITRUVIUS

BOOKS I—V

INDEX OF ARCHITECTURAL TERMS

NOTE.—This index is limited to terms used or implied by Vitruvius. He wrote in the vernacular as distinguished from the literary idiom, and with a view to practice. Comparison with inscriptions both Greek and Latin shows that there was a traditional technical language used by builders, and it is fairly represented by the Latin text of *H.* Latin terms are in italics. Where they correspond closely to the corresponding English terms, they are sometimes left untranslated.

Abacus, πλίνθος, thin flat slab usually square at top of column under architrave, 187

Abaton, ἀβατον, sanctuary which is not to be entered, 125

Acanthus, ἀκανθος, Brank-Ursine, a plant of which the leaves are imitated in Corinthian capitals, Pl. D., 209

Acroteria, ἀκροτήρια, pedestals on the centres and sides of pediments, 195

Amphiprostylos, ἀμφιπρόστυλος, buildings with a portico at each end, Pl. B., 167

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Antae, παραστάδες, the pilaster-formed ends of walls, 166

Apophysis, ἀπόφυσις, the hollow curve with which the base passes into the shaft of a column, Pl. C., 241

Apse, ἄψις, a semicircular or polygonal recess, Pl. H., 309

Araeostylos, ἀραεόστυλος, with wide intercolumniation, 171

Architrave, ἐπιστύλιον, that part of the entablature which rests upon the columns, Pls. C. and E., 191

Asser, ἰμάς, small rafter, lath, 213

Astragal, ἀστράγαλος, a convex moulding with long and short beads, 187

Axis, ἄξις, the centre of a volute, Pl. C., 188; *vern.*, a plank, 212, cf. *Caes. B.C.* II. 9

Base, βάσις, the lowest part of a column, Pl. C., 207

Basilica, βασιλική, a lawcourt, 257

Bed, *cubiculum*, the level surface on which a brick or stone or joist is laid, 216

Bedjoint, *cubile*, ἀρμυς ὑπτιος, the mortar or cement filling in, between the bed and the material above, 113

Bond, *coagmentatio*, ἀρμογία, the overlapping of bricks or stones in a wall, 115

Bondstone, *diatonos*, διάτονος, κραυγῆς, a stone stretching through wall, 117

Bricks, *lateres*, πλίνθοι, made of sun-dried clay, used until the end of the Republic, 116

Burnt bricks, *testae*, πλίνθοι ὀπταί, kiln-baked bricks, came in with the Empire, 126

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Cella, σηκός, interior of shrine, 226

Coliculi, *vern.*, perh. καύλιον, Hesych., stalks in a Corinthian capital, 211

Clamp, *ansa ferrea*, δέμα, band of iron for holding things together, 113

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Column, *columnna*, κίων, an upright which includes base, shaft and capital, 177

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Corona, see Coping and Cornice

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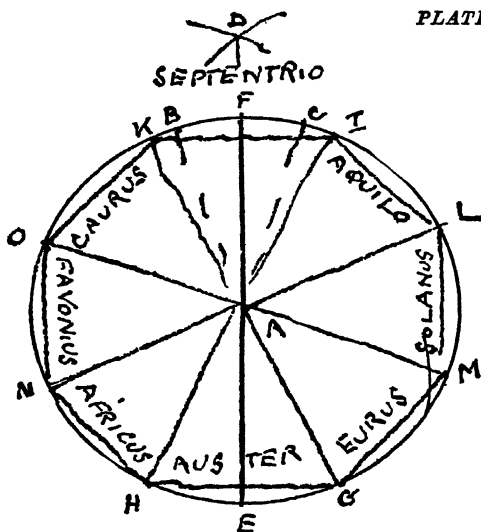
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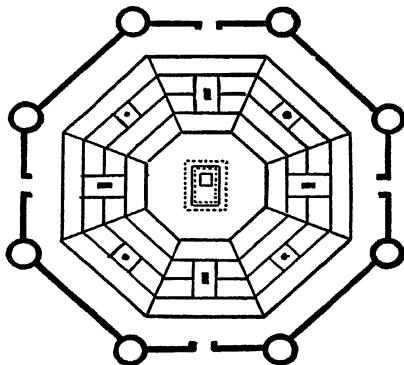
- diaper pattern of diamond-shaped faces of stone or other material, 111
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- Zophorus, ζωφόρος, frieze, middle part of entablature, 193



DIAL OF WINDS

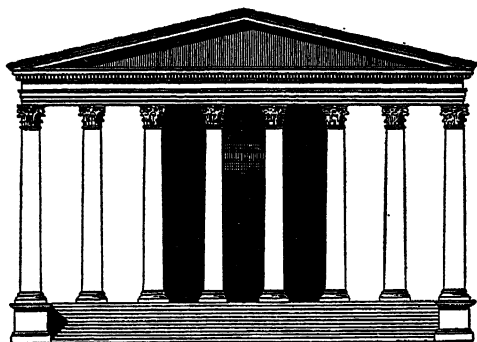
[Book I. vi. 12. H.]

The dotted lines A-B and A-O mark the shadows as taken before and after the midday shadow A-F. D is the intersection of circles struck from B and C in order to give the meridian shadow, and D-E gives the meridian line.

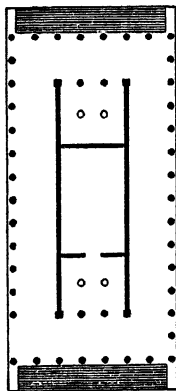


PLAN OF TOWN

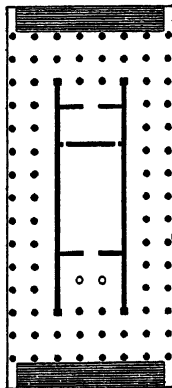
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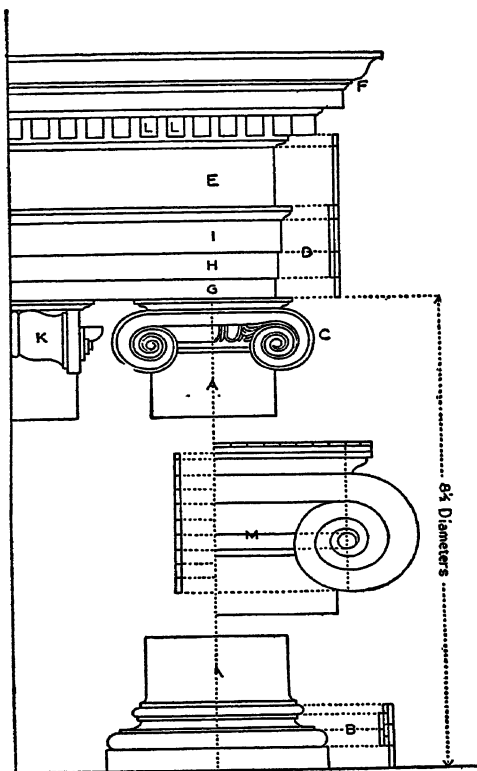
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IONIC ORDER

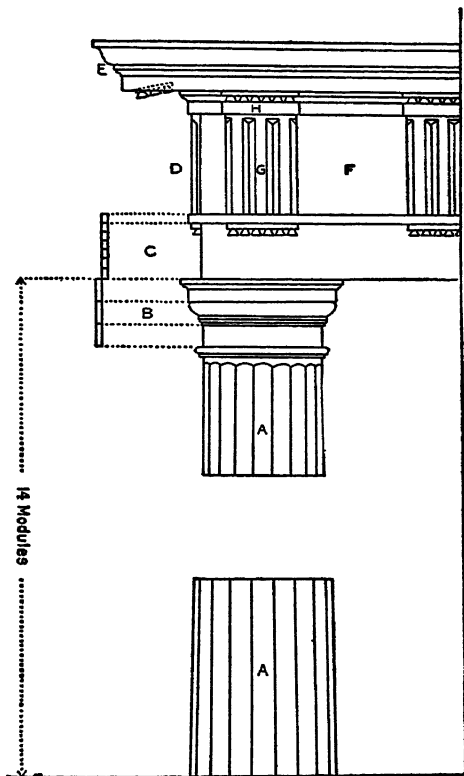
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- A. Shaft.
- B. Base.
- C. Capital.
- D. Architrave.
- E. Frieze.
- F. Cornice.

- G. Fascia.
- H. "
- I. "
- K. Volute.
- L. Dentils.
- M. Volute to a larger scale.



The Capitol Drugga.



DORIC ORDER

Book IV. iii.

- A. Shaft.
- B. Capital.
- C. Architrave.
- D. Frieze.

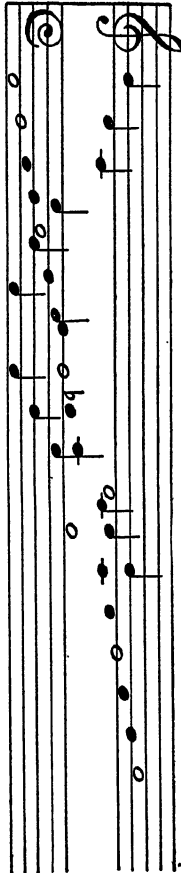
- E. Cornice.
- F. Metope.
- G. Triglyph.
- H. Capital of Triglyph.

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- Book V. iv. 5.
- Proslambanomenos.
- HYPATON.
- Hypate. }
 Parhypate. }
 Lichanos. }
- MESON.
- Hypate. }
 Parhypate. }
 Lichanos. }
- Mese.
- SYNHEMMENON.
- Trite. }
 Paranete. }
- Nete.
- Paramese.
- DIEZEUGMENON.
- Trite. }
 Paranete. }
- Nete.
- HYPERBOLAEON.
- Trite. }
 Paranete. }
- Nete.

Fixed Notes: Breves.
 Movable Notes: Crotch-
 ets.



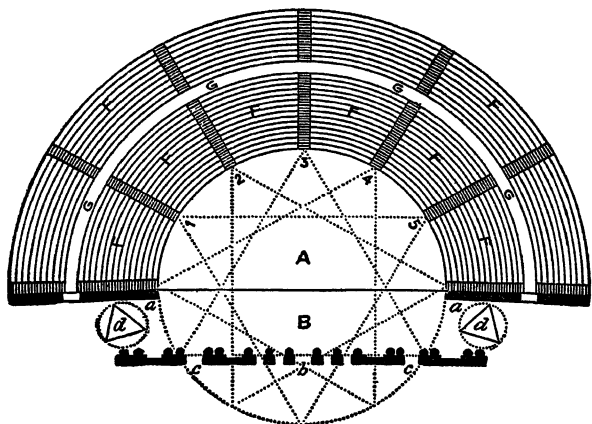
HARMONICS

TUNING OF TOP ROW OF VASES.

- Book V. v. 2.
- Hyperbolaeon.
- Diezeugmenon.
- Synhemmenon.
- Meson.
- Hypaton.
- Proslambanomenos.
- Mese.
- Proslambanomenos.
- Hypaton.
- Meson.
- Synhemmenon.
- Diezeugmenon.
- Hyperbolaeon.

The above notes have
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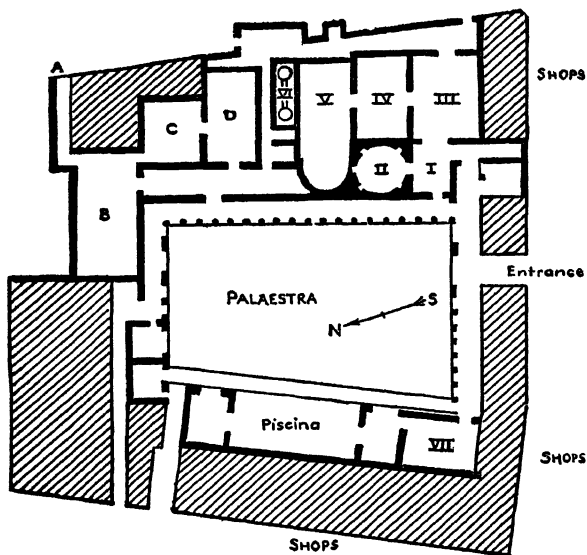
PLATE G.



ROMAN THEATRE ACCORDING TO VITRUVIUS

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- II. Frigidarium.
- III. Apodyterium.
- IV. Tepidarium.
- V. Caldarium.
- VI. Furnace.
- VII. Apodyterium.

WOMEN'S BATHS.

- A. Entrance.
- B. Apodyterium.
- C. Tepidarium.
- D. Caldarium.

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VITRUVIUS
ON ARCHITECTURE
BOOKS VI-X

EDITED AND TRANSLATED BY
FRANK GRANGER



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PREFACE

IN bringing to completion an attempt to base the text of Vitruvius on a single primary MS. the critical notes below the Latin text of Books VI. to X., continue the evidence of Books I. to V. to the excellence of *H.* While the emphasis of the first five books is upon architecture in the usual sense of the word, the second five books disclose the world of Greek science as a background to engineering and restore the full picture of Vitruvius.

Mr. Frank Richards, M.A., the translator of the *Aeneid*, has given me valuable help in the final revision for the press. Nor must the printer's reader be left without thanks for his continuous and scholarly co-operation.

FRANK GRANGER.

UNIVERSITY COLLEGE,
NOTTINGHAM,
July, 1933.

INTRODUCTION

VITRUVIUS AS THE HISTORIAN OF SCIENCE

IT is only in modern times that Vitruvius has been regarded mainly as an architect, and that attention has been almost concentrated upon his exposition of the orders of architecture to the neglect of the major part of his achievement. Not unnaturally the expectation has been raised that his style should exhibit the qualities of order, arrangement and symmetry which he somewhat confusedly traces in architecture, Book I. ii. 1. If with more propriety we follow tradition and approach him as an engineer, the case is altered. As Caspar Barth¹ well puts it according to Morhof: *est styli genus . . . coactim nimirum eruditionem Graecam sapiens, et manum opificis, non ingenium scriptoris, olens*. "His style in a word combines Greek science with the touch of the craftsman rather than the manner of the writer." In this respect he anticipates the two most universal geniuses of the Renaissance. Michael Angelo's "style is obscure, crabbed, ungrammatical."² Again, "Italian scholars declare that Leonardo's grammar is that of the small Florentine shopkeeper."³ But, for

¹ *Polyhistor*, I, Book IV. xi. 17.

² Symonds, *Life of Michelangelo* (1893), Vol. II. 168.

³ Müntz, *Leonardo da Vinci*, tr. (1898), Vol. II. 22.

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all that, he was a brilliant and accurate man of science.¹ Vitruvius, also, illustrates the not infrequent separation of scientific insight from the command of literary expression. Yet his style is well adapted to the needs of the laboratory and workshop.

Like Leonardo, Vitruvius records experiments and their uses: a lighted lamp as a test for foul air in a well, ii. 191; the effects of white lead on those who work it and the consequent danger of lead pipes in the supply of water, ii. 189; the vibration of bronze in response to the use of iron implements in a neighbouring tunnel and the consequent military precautions, ii. 367. Over against such experimental results were the mathematical principles, almost confined to geometry owing to the imperfect notation of numbers, and the resulting cramping of arithmetic. The geometrical achievements of the Greeks were stimulated by the empirical formulae of Egyptian builders and the astronomical observations of the Chaldaeans. But the sense of the universal came first in Hellas to its complete expression and carried geometry no less than metaphysics to levels not often reached in after times and rarely transcended. The inspiration of science no less than that of literature and of art was attributed to the Muses, and Vitruvius adopted this as an article of his creed from a legend about Pythagoras, ii. 203.

The realm of natural science was almost alien to the Athenian mind, so richly endowed in other fields.² The *Clouds* of Aristophanes and Plato's *Apology*, exhibit from two angles, that of the con-

¹ Mach, *Science of Mechanics*, tr. (1902), 520.

² Diels, *Vorsokratiker*, ii. 83, 116.

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servative and that of the moralist the disinclination of the Athenian intellect towards natural science. Plato and Meton are almost the only Athenians whose works appear in the history of science.

Vitruvius, in the preface to Book IX., traces the development of geometry from its beginnings to the solution of the Delian problem, the duplication of the cube. Later on in the same book he enumerates the astronomers in whom he traces the operation of the divine mind, ii. 247. The founders of scientific geography, ii. 175, opened out a subject which still awaits full fruition. If we assign the thinkers whom Vitruvius enumerates to their places of origin we might be led to infer that Asia Minor, Macedonia, Sicily, Southern Italy were more receptive of scientific inspiration than Attica. For the Athenian temper shrank from applying science to the observation of nature, and Plato treated Democritus with silent disapproval, incorporating in the *Timaeus* with the disdain of the abstract thinker, the *specific* observations of Democritus.¹

The legendary wish of Plato to destroy the works of Democritus was countered for the time by their wide circulation; the catalogue made by Thrasyllus, himself a Platonist, contains evidence not to be neglected of their survival into the first Christian century. Hence the importance of Vitruvius as bridging "the gap between the dominating idealism of Plato and Democritus' rational observation of nature with its anticipation of modern theories."² We owe to *H* and its descendant *h* the correct state-

¹ Zeller, *Phil. der. Griechen*, II. i. 791.

² Heiberg, *Geschichte der Mathematik u. Naturwissenschaften im Alterthum*, 12.

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ment of Democritus' theory of perspective, ii. 71, which follows from his principle that "things" are not real but dependent upon "atoms": a principle which is parallel to the dependence of things upon the Platonic "ideas," ii. 89. It is the presence of Democritean principles in the background of the *de architectura* that rescues it from a purely archaeological interest. Neither Platonism nor the Church is to blame for the disappearance of Democritus, who was represented in the public libraries of the early empire. Like the greater part of the Greek literary tradition, Democritus disappeared in the confusion which followed upon the assassination of Alexander Severus A.D. 235.

VITRUVIUS AS THE HISTORIAN OF MACHINERY

Compared with Greek science, Greek mechanics was in its infancy.¹ The backward state of metallurgy almost limited the mechanical engineer to the occasional use of bronze. Ancient artillery itself was constructed of wood and operated by elastic tension like a bow. Vitruvius carried his manual to the middle of the tenth book before he thus turned from the service of peace to that of war, ii. 325. The practical character of his definitions is shown by the fact that catapults and balistae have been constructed and operated in modern times by following his rules.² The plates at the end of this volume show how water-power was applied to clocks and organs and other purposes of peace. The application

¹ Mach, *op. cit.*, 520.

² Neuburger, *Technical Arts and Sciences*, 222.

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of water-power to time-pieces and automata was controlled by a balancing weight of sand. The principle of equilibrium involved is correctly named by *H*, ii. 275, but has not been so understood by the editors; it furnishes the difficult problem of virtual velocity. More simple cases are found in the principle of the balance, and of the lever. We must be content with this glimpse into ancient mechanics, of which the theoretical importance went far beyond its achievements in practice. Its weakness in this respect was partly compensated by slave labour which was brought in to work the capstans of pulleys, ii. 285; water-wheels, ii. 303; treadmills, ii. 309.

Generally speaking skilled labour seems to have been free, and to have enjoyed a status somewhat higher than in modern times. The precautions taken against poisoning by gases or by lead have a strangely modern sound, like the baths and public libraries which were soon established even in towns of a moderate size all over the empire.

Building artificers were organised into *collegia* or benefit societies and often worked in gangs of ten, *decuriae*, under a foreman, *decurio*. The plasterers, ii. 95, were probably freemen; the paviours may have been slaves, ii. 83. They were engaged and paid by the works manager, *praefectus fabrum*, a term replaced by "architect." Vitruvius contemplates the case in which the owner acts as his own works manager, ii. 9.

He wrote for the foreman and the works manager, and his book sheds a light upon the social conditions of the early empire comparable to that furnished by the New Testament. The evidence furnished by the latter, however, is blurred in the English Authorised

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and Revised Versions by the mistranslation of *doulos*, which in the 120 places in which it occurs is never correctly translated "slave" in spite of the Latin versions which always give *servus*. Throughout the N.T. the artificer is usually a freeman,¹ and yet he is repeatedly identified with the slave by the use of "servant" for both the slave and the free employee.

It was the free artificer working for Christian employers who created the early Christian art, which came to perfection by the third century, and anticipated the mediaeval art to which Vitruvius' *de architectura* also served as a manual.

¹ Granger, *Legal Status of Labour in the N.T.* Nottingham, J. and H. Bell, 1933.

VITRUVIUS AND THE CRAFTSMEN OF ROME¹

I

THE Roman craftsmen were scarcely disturbed during the first three centuries of the empire by the political catastrophes which transformed the Roman state into an Oriental despotism. They displayed their traditional skill impartially in the service of the imperial religion and of the Christian clients who, as time went on, became its passive opponents. From Augustus to Diocletian the reigning monarch was a patron of the arts and added to the architectural splendours of the capital. Increased knowledge has shown that the church itself fostered no less some of the finest achievements of the Roman tradition.

Over against this conservatism of the capital and indeed of the western provinces, Christian buildings in the east took another turn. For example, the earliest churches of Old Cairo² date at least from the third century. Similarly, Syria, Asia Minor, and North-west Africa seem to have preceded the west generally in the construction of churches as distinct

¹ Many years ago Professor Burkitt called my attention to Richter and Taylor's *Golden Age of Classical Christian Art*. A similar thesis is elaborated in the following pages. The historian of Roman Art must include a survey of the Christian material.

² Butler, *Ancient Coptic Churches of Egypt*, 1. 2.

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from the use of secular buildings for religious purposes. The eastern architects made large use of domed structures, while the architects of the west were able to develop their designs, with but little variation, from the form of the basilica as the Romans knew it. Against such a background Roman craftsmen, not necessarily Christian, felt themselves at home.

Classical Christian art was thus the prophecy of the new world which was to rise upon the ruin of the empire of Augustus. It is the eastern development of Christian architecture which is the basis of theories like that of Josef Strzygowski, which would derive not only architecture but other forms of Christian craftsmanship from Oriental sources. But while we trace the influence of Roman tradition as formulated by Vitruvius, we vindicate for the west a leading part in the painting, sculpture and minor arts of the first three Christian centuries.

The craftsmen who carried out the commissions of Christian clients enjoyed the protection of the State. For the form of imperial government inaugurated by Augustus, the patron of Vitruvius, was directed towards the supremacy of Roman law, not only as embodying Roman traditions but as allied to the universal principles of justice. It was Stoicism that effected this union and spoke from the Roman throne by the lips of Marcus Aurelius. To be a Roman citizen was to enjoy legal protection, extended to every race within the imperial borders, including Jewish artisans like Paul the tentmaker. We can trace the free craftsmen during this time: the architect and the physician no less than the paviour, the mason, the carpenter. For the empire brought freedom not only to artificers but to pro-

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fessional men. Cyrus and Chrysippus, two of Cicero's architects, had been slaves; so too Hyginus, the keeper of the Palatine library under Augustus; so too Antonius Musa, the emperor's physician. But this servile status was a passing circumstance due to the subjection of Greece by Sulla in 86 B.C. In the case of "architects," the Latin equivalent *praefectus fabrum* was often used as an honorific title. The extension of Roman citizenship by Caracalla to all communities in the empire was accompanied by the parallel extension of Roman law, thus completing a process already begun by the Julian emperors.

The Roman craftsmen served the extension of the scheme of empire. Vipsanius Agrippa and Asinius Polio¹ were the two greatest administrators of Augustus, and, between them, determined the material outlines of his great design. In order to understand the picture of the Roman world, we must set them in a higher relief than the historical tradition seems at first sight to admit. Agrippa combined in one person the general, the statesman, the savant, the engineer and the loyal friend of Augustus. Six words of Paterculus make the portrait: *uni parens . . . scientissimus . . . consultis facta coniungens*. Polio is the complement of Agrippa. While Agrippa surveyed the geography of the empire, its roads and cities, Polio assembled the literature and science of the time in the first public library in Rome, and thus "made human genius a common possession." His library was also a museum of sculpture and painting, a precedent which was widely followed. Hence he is coupled as an architect

¹ The spelling varies between Polio and Pollio.

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with Vitruvius in the *Epitome* of Faventinus. By an extraordinary blunder "Polio" was regarded as the cognomen of Vitruvius!

For the term "architect" which includes the engineer, is also applied to the controller of libraries. Polio like Agrippa and Vitruvius was one of Pliny's authorities for the *Natural History* so far as that describes the state of the empire, its roads and cities, its background of history and craftsmanship. The loss of Polio's history from 60 B.C. to the battle of Philippi is due perhaps to his hostile criticism of Caesar and Cicero, and to an archaising and rugged style; his masculine grasp of facts, however, left its mark upon later historians—Suetonius, Tacitus, Plutarch,—and his realism was a powerful antidote to the rhetoric in fashion. Through him we understand how Vitruvius and the elder Pliny and above all Augustus himself in the *Monumentum Ancyranum* could dispense with the graces of style in the presence of their mighty theme.

Augustus and Pliny describe the material embodiment of empire as thus realised. Vitruvius furnishes the precepts by which succeeding generations were guided in their undertakings. His work seems at once to have become authoritative, not only as regards the classical orders of Books III. and IV.—his rules, indeed, can be traced in Spain as well as Africa—but rather as a manual of construction and of technical processes generally.

II

The survey of the empire made by Agrippa was exhibited by him in two forms: one in a map (per-

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haps plotted on a sphere) in the Porticus Vipsania, the other, by way of description, on the pages of his geographical commentaries. The latter went little beyond statistics, and enumerated the dimensions of known lands and seas, the course of the roads and the sites and distances of cities, as well as of natural features such as rivers and mountains. Agrippa, indeed, furnished much of the material assembled by Pliny the Elder in the geographical books of the *Natural History*, but Pliny often falls into inaccuracy when he leaves the official statistics of the empire. We can trace in his work, however, the material of the itineraries which Vitruvius himself used. The latter defines the position of places by reference to the roads, but we need not assume that he had himself traversed them when he refers to the road to the temple of Ammon¹ or to the road in Cappadocia between Mazaca and Tyana.² The rich and, in the main, accurate geographical references of Vitruvius are on a level with the rest of his work. He blends the scientific geography of Greece with the measurements of Roman surveyors and furnishes the description of the odometer³ by which distances are measured by sea as well as on land. On land the odometer supplemented the measurement by paces of which every thousandth was marked, hence the "mile."⁴ Vitruvius, in his account of pavements,⁵ gives a specification which is appropriate to roads of elaborate construction and uses terms of general application to roadmaking. He also refers to the use of piles upon made ground

¹ Book VIII. iii. 7.

² Book VIII. iii. 9.

³ Book X. ix.

⁴ Strabo, 322.

⁵ Book VII. i. 3.

VITRUVIUS AND THE

like those driven by Germanicus¹ over the marshes of Westphalia, an expedient often necessary because the Roman engineers went on their way regardless of marshy ground.

Along with the making of roads came the construction of permanent camps (where there were no towns) to mark the route or destination of these military highways. Vitruvius' rules for fortification, and for laying out the spaces so enclosed,² are not applicable to the small town formed by a permanent camp. He rather lays down the general principles of town-planning.³ But there is one feature in Greek and Roman town-planning which escapes the great blemish in modern colonisation, the loneliness of the settler. Instead of sending the separate colonist or group of colonists to settle where chance might conduct, a suitable site was chosen and a large part of the town laid out and constructed. It is true indeed that the colonies in the provinces under the empire were mainly of a military character, but this does not affect the value of the architectural precedent. Of this Timgad is a complete type. It was founded under Trajan A.D. 100 and completed within twenty years. It lay on the road from Theveste to Lambaesis, and the road itself formed the main highway of the town. The architects who were engaged took with them the methods of construction described by Vitruvius, and the soldiers of the Third Legion laboured upon the works which were to furnish them with a military depot and a home.

The beauty of these foundations took account of

¹ Tac. *Ann.* I. 61.

² Book I. v.

³ Book I. cc. iv, vii; Book II. pref.

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practical needs. The successive inventions of the Romans were directed towards the comfort, the warmth and dryness of interiors. The strong brick walls and the few openings which made the private house secure on the outside, passed to the baptistries and basilicas of the church.

The system of heating by "hanging floors" raised upon small pilasters of brick is described by Vitruvius.¹ In the space so formed hot air circulated from a furnace. This contrivance is said to have been invented by L. Sergius Orata,² c. 100 B.C. It was first applied to baths and then to private houses. The numerous remains of Roman villas in Britain suggest that in this way the terrors of our English winters were alleviated. Such an invention would naturally commend itself to the Roman victims of malaria like Maecenas, who indeed is credited with the first hot swimming bath. Agrippa extended the luxury of the bath to the populace by leaving to them in his will his gardens and his baths,³ "so that they might bathe gratis." The baths furnished a popular lounge and were even supplied with libraries,⁴ a circumstance in which architectural evidence supplements the silence of literature.

Yet the farm gained also. There is a typical representation on a mosaic in the museum at Tunis. The farm-houses of the earlier republic were finer than houses in the town,⁵ but the case was reversed under the empire. Vitruvius, even so, has to warn the farmer against allowing his taste for architectural elegance to interfere with the needs of agriculture.⁶

¹ Book V. x.

² Dio Cass. LIV. 29.

³ Varro, *R.R.* I. xiii. 6.

⁴ Plin. *N.H.* IX. 168.

⁵ Platner, 522.

⁶ Book VI. vi.

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The decline of the small-holder and the growth of *latifundia* was compensated by the growth of the tenant class, without whom the working of the large estates would have been impossible. The spread of the security which was assured through Roman law brought with it the revival of the country-side. Virgil's picture of the old farmer with his small plot¹ may be taken along with Horace's five tenants who went to market and voted in the elections at Varia.² Vitruvius' instructions about farm-houses are suitable for small as well as large farms.³

But the contrast between the countryman and the townsman was often present to the Roman mind. Not for the countryman, the resources of the larger towns, the baths, the theatre, the libraries, the rhetorical and poetical displays and—for the more general taste—the games in the amphitheatre. Yet the increasing sense of the beauty of landscape and of pastoral life and the enjoyment of a safe obscurity were motives not without effect. The multiplication of colonies throughout the empire furnished markets for farm produce and so enabled the countryman to pay his way. The municipal storehouses were amongst his best customers.⁴

But where the land was worked by slave labour, the contrast for the slave was all in favour of the town. The slaves who performed their duties in the large houses of the great cities were in some respects better placed than the free craftsman or small trader. In the country, slave labour worked the wine and oil presses,⁵ the water-wheels, the

¹ *Geor.* IV. 125 ff. ² *Ep.* I. 14. 3. ³ Book VI. vi.

⁴ Book V. ix. 8. ⁵ Book VI. vi. 3.

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flour-mills.¹ In the town-house, the architect had regard to the convenience of the slave himself.²

III

But Roman comfort was carried to the extreme of luxury. And the greatest minds followed in the train of the sensuous grandee. Cicero's palaces were to be found not only in Rome where he bought Crassus' house on the Palatine, but at Tusculum, where he had a magnificent place which once belonged to Sulla. And there were others at Antium where he kept his library: at Astura, a little island off the coast of Latium, where he retreated for solitude, besides country houses at Arpinum and on the coast of Campania. The sculpture and painting of Greece made the contents of his mansions scarcely less costly than the mansions themselves. All this gives point, perhaps intended, to the contrast severely drawn by Horace between the unhappy splendour of the palace by the sea and his own peaceful farm in a Sabine valley. Augustus ranged himself on the side of Horace. His modest house on the Palatine, his furniture, his home-made clothes verged upon the stingy. Yet his public undertakings were splendid. The marble which he claimed to have substituted for brick at Rome refers not less to the incrustation of interiors than to the columns and sculpture outside. As time went on, public amenities grew out of private undertakings. We shall see the municipal library and the Christian basilica springing from the Roman palace. The basilica is

¹ Book X. v. and vi.

² Book VII. iii. 4; iv. 5.

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represented magnificently by Sta. Maria Maggiore and its mosaics.¹

It is a strange episode in the history of philosophical sects that Horace and Augustus, who represent the simplicity of private life, should have inclined to an Epicurean standpoint, while Seneca, the eminent Stoic moralist, should have overtopped the monarch himself in the amenities of his parks and the magnificence of his country houses.² Yet it is possible that Roman taste was not immediately offended by the contrast between the profession of the Stoic creed and Seneca's vast accumulations of wealth. Vitruvius in a striking passage³ declares that professors of rhetoric must be housed with distinction and in sufficient space to accommodate their audiences, while high officers of state must have parks and majestic avenues of trees and palaces with libraries and basilicas finished in the magnificence of public buildings. In judging Nero, therefore, we are met by the question whether Seneca by declining the "gardens, the money, the country houses lavished on him"⁴ by Nero would not have lost some of his influence over his pupil. The same passage of Vitruvius illustrates two episodes in the life of Nero's contemporary, St. Paul. After giving a rhetorical display at Athens which sheds some light on the kind of lecture he was to deliver for nearly four years, he taught for eighteen months at Corinth in the mansion of Titius Justus. He also lectured for two years in the "lounge" *schola* of a wealthy citizen of Ephesus, Tyrannus,⁵ who may himself have

¹ Richter and Taylor, *op. cit.* ² Tac. *Ann.* XIV. 52.

³ Book VI. v. 2.

⁴ Tac. *Ann.* XIV. 55.

⁵ *Acts* xix. 9.

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been a rhetorician. It is noteworthy that the apostle's second and third journeys almost coincided with the five years in which, under the control of a soldier and a rhetorician, the empire was well governed. Paul's experiences on the sea are a striking evidence of the peace which reigned. To the outer world Paul would present himself at first not so much as a teacher of religion but as an example of the numerous and characteristic class of peripatetic orators whose displays were a popular form of entertainment. Their fees were on the scale of those given to a prima donna in our time. We shall see later how the large apartments in which such shows were held, passed easily into the forms of the church-building.

The rhetorical business, therefore, was one of the most profitable of the day. That Christian teachers should generally (but not always) refuse remuneration brought them into line with other cases, relatively few, found especially among the Stoic sect. But these exceptions did not affect the general view. Hence the silversmiths' trade union at Ephesus would regard Paul from the economic standpoint,¹ as a dangerous rival who threatened a business which furnished useful employment to many persons. That the silversmiths raised the cry "religion in danger" was a natural move. Ephesus gained much from the presence of a widely popular shrine, although it is certain that many who shouted the loudest were, as far as Artemis went, disbelievers at heart. The case of the coppersmith, to whom we owe the exquisite works in bronze like those found at Pompeii and elsewhere, was the same with that

¹ *Acts* xix. 25.

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of the silversmith. The hostility of Alexander the coppersmith¹ towards St. Paul may have had a business basis. But this conflict between the Church and the craftsman was a local and passing phase. In most places the artisans who became Christians continued at their trade and carried over into Christian art the themes of Greek mythology. They also shared in the reaction against the unreality of the public lecture-room with its veneer of philosophic jargon over a rhetorical background. For their growing realism in building and the allied trades went hand in hand with the science of the day: its experiments which anticipated modern chemistry, its advances in mechanics, its presentation of spatial problems in a geometrical rather than an analytic form.

But the new realism which we shall trace in the development of classical Christian art found its fierce background in the service of the arts towards the maintenance of the Roman empire. Vitruvius the engineer was compelled at the end of his work to "turn from the machines which may be carried out for useful purposes or for amusement in times of peace and tranquillity" to "the inventions which serve both to protect against danger and to satisfy the needs of safety." Such was his interpretation of the military engineering which the empire demanded.² Apollodorus, a Greek architect from Damascus, followed this example and after executing some magnificent schemes of Trajan, constructed a military bridge over the Danube for Hadrian, to whom also he dedicated a famous work on siege tactics. The Forum of Trajan had for its focus the

¹ 2 *Tim.* iv. 14.

² Book X. ix, x.

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Column with its spiral relief recording with the detail of a careful historian, and after no long interval, the emperor's Dacian campaigns.

The intention of the sculptors was, so to speak, living portraiture, like the figures at Madame Tussaud's. (It is possible that the column was coloured.) But this masterpiece of realism had been anticipated in the reliefs of the Arch of Titus, in which the figures stood out from the background in such a way as to produce an effect of aerial perspective. The discovery of perspective and its application was made in the time of Pericles.¹ It controlled the dimensions of the Parthenon,² revolutionised painting, and affected the working of gems.³ Perspective anticipated photography in its presentation of the real, and the history of painting and sculpture might be regarded as alternate reactions from, and towards, perspective treatment. In a striking passage Vitruvius demands "imitations taken from reality,"⁴ and thus announces the tendency of imperial Roman art towards the "illusionism" formulated by Wickhoff. But this is more than a technical motive: in the Column of Trajan it is employed to furnish a visible counterpart of the *Monumentum Ancyranum* of Augustus. The artist does not shrink from the full presentation of warfare, its horror no less than its victories. If in one piece Trajan is shown receiving the submission of the Dacians,⁵ in another, Roman army surgeons

¹ Book VII. pref. 11.

² See my article "The Parthenon and the Baroque," *J.R.I.B.A.*, 1931, 735 ff.

³ Pl. K and note.

⁴ Book VII. v. 3.

⁵ Strong, *Roman Sculpture*, Pl. 55.

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are shown tending the wounded, whose suffering is indicated by their attitude; and in yet another Dacian women torture Roman prisoners.

Whereas, therefore, oratory had declined into rhetoric with the limitations of political freedom, sculpture and painting took fresh life in the presentation of the real. "Here also is a tear for human lot" in the beauty of the *landscape* against which the human tragi-comedy is presented.¹ But the later editors, following Fra Giocondo, have substituted *gardening*² and thus weakened the emphasis which is demanded. The sculptures of Trajan's Column end with beautiful landscapes, a mountain lake by day and again the goddess Night brooding among forest trees over a lonely shed in which two Dacians are going to their rest.

IV

The garden has been the vestibule to landscape. But gardening was scarcely known to the Greeks, at least in the current sense, until Alexandrian times. In Egypt, however, gardens and parks were found as early as the Old Empire, and beer—the national drink—was accompanied not only by bread but also by the indispensable "flowers of yesterday and to-day."³ Hence the Greek palaces of Alexandria took over into their peristyles the plants which the Egyptian gardeners trained. In the more temperate climate of Italy horticulture was less dependent on

¹ Book V. vi. 9.

² *topiarii* for *topeodi*, with which we may perhaps compare ἀργειώδης from ἀργείοι.

³ Erman, *Life in Ancient Egypt* (tr.), 194.

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irrigation. The garden spread out into the park adjoining the house, and the architect in his planning provided windows to overlook the garden.¹ Nor was Persian precedent without its effect. The brilliant city of Cyzicus, long dependent upon Persia, gave its name to large rooms with folding windows and a northern aspect, opening upon gardens. For these the precedent was to be found in the "paradises" of the Persians, first mentioned by Xenophon. That Cyzicus should give a name not only to "*oeci*" but to "*triclinia*"² was probably due to its architectural tradition.

The city possessed three official architects in control of public buildings and machinery.³ The Greek and Roman architects, therefore, like Kent and Capability Brown and Repton in eighteenth-century England, helped to change the face of the Roman empire to the beauties of Italian and other landscape.

The limitations which we have traced in Attic culture, its alienation from science and its insensibility to nature other than human, were the price paid, and profitably paid, for its unassailable supremacy within the limits marked out by itself. After thus mastering one field, the human spirit went on to fresh conquests. Hellenistic and Roman culture are not, therefore, to be regarded as cases of degeneracy from Atticism, but rather of movement into fresh fields.

We have traced the history of science. The coming of landscape into the human view deserves special consideration. Theophrastus, one of Vitruvius' authorities, reached the highest level

¹ Book VI. iii. 10.

² Book VI. vii. 3.

³ Strabo, 575.

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which antiquity attained in descriptive natural science. His botanical works inspired Vitruvius' account of Italian timber,¹ and his mineralogy guided the descriptions of marble and mineral pigments and less precious materials in the seventh book. Vitruvius' interest in gardens is especially shown by two passages² in which he lays down the principles which still govern the lay-out of Italian gardens such as the Pincio, the *collis hortorum*; his insistence on well-constructed paths and on the use of trees for shade is still respected. In the gardens of Jerusalem and neighbourhood, the olive gardens west of Jerusalem in the time of our Lord were of the Italian type and the view of the Temple from Gethsemane anticipated the view of St. Peter's from the Pincian.

Vitruvius' casual references to medicine are rather concerned with regimen. The anatomy of the fauna which along with the flora characterised the landscape, was little understood. Galen³ of Pergamus was still to come, and carry anatomy to the point which was not to be transcended for eleven hundred years—in this respect the Dark Ages beyond doubt—which elapsed before the coming of Mondino of Bologna. The scene on Trajan's Column where an army surgeon attends to the wounds of a soldier discloses the source of the advance in the anatomy of the limbs. Superstition, soon to regain its sway, opposed as far as it could the dissection of the human body.

¹ Book II. ix. x.

² Book V. ix. 5; xi. 4.

³ A.D. 129-199.

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V

The elaborate presentation of detail on a large scale that can be traced upon the Column of Trajan and on the scarcely inferior Column of Antoninus served historical purposes. To stigmatise as pedantic this attention to detail is to misunderstand the meaning of the "realist" movement. Rather should we acknowledge the technical mastery which is displayed, first on this large scale, and secondarily in the sarcophagi of the second and third centuries, culminating in the sarcophagus of the Capitol, representing Achilles at the Court of Lycomedes.¹ This sarcophagus also marks the end of the period before us. We can thus trace a period of three centuries from the accession of Augustus to the death of Mamaea, A.D. 235, in which there is advance in science and no trace of degeneracy in craftsmanship.²

¹ There is a cast in the British Museum.

² The traditional identification of the reclining figures on the lid as Mamaea and her son Alexander Severus is obviously incorrect, as regards the latter. The man, according to precedent, is the husband of the woman. Her "hairdress is that of the Princesses of the Emesene dynasty." * I do not think that this fact has been sufficiently regarded. It supports the identification of the woman with Mamaea. In that case the man represents her husband Gessianus, the father of Alexander. The identification of Mamaea has been rendered more difficult by the unfortunate restoration of the bust of Mamaea in the British Museum. Mamaea, if we may judge from the two fine busts in the Louvre,† and from most

* Mrs. Strong, *Roman Sculpture*, 319.

† Nos. 1075, 1336. There is a third bust, 1053, which is doubtful. To pass from the sarcophagus of the Capitol to the first two busts is a convincing proof of the identification proposed.

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The reign of Mamaea, A.D. 223-235, was in many respects the most brilliant episode in the history of Roman well-being. Ulpian, the peer of the great jurists whom he succeeded, Salvius Julianus and Gaius, and along with him Dio Cassius, the able historian of the empire, were the ministers of Mamaea in her financial and economic measures. A papyrus fragment¹ adds a third name, Julius Africanus, who filled the post of imperial librarian, a soldier, an engineer, and a Father of the Church. As the Director of the Pantheon library, he was at the head of the movement which provided even small provincial towns with public libraries. In this capacity he advised the empress in other matters as well; the sculpture, for example, which furnished the busts of authors to accompany the library shelves. To him was probably due the placing of the imperial sarcophagus in its hiding-place, the Monte del Grano, where it was preserved for thirteen centuries until its discovery in 1582. The assassination of the empress and her son at Mainz in 235 marked the end of the scheme of empire laid down by Augustus, described by Vipsanius Agrippa, and receiving a material embodiment in accordance with the precepts of Vitruvius.

of the coins which bear her superscription, had a profile not unlike that of Queen Victoria. But the British Museum bust, like so many others, had a broken nose, and the restorer added a nose not unlike Ellen Terry's. Leaving this bust out of account, we may regard the sarcophagus as prepared during Mamaea's lifetime to receive, ultimately, her ashes.

¹ *P. Oxy.* III. 412.

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VI

The exterior peace which is so illusive (high prosperity such as that of Mamaea's government preceded the collapse of the old Roman order) passed into an interior peace, that of the Church. But so long as the old order continued, the Christian community made use of the traditional craftsmanship, and of this tradition Vitruvius was a guardian. Two centuries after the death of Mamaea, Sidonius Apollinaris, in his letters,¹ quotes Vitruvius as the typical architect. Amid the general decline of science, the craftsman received a glimmer of light from Vitruvius. To return to art, there was no general prejudice in the early Church against the employment of the Greek and Roman myths as the topics of ornament. Alexander the coppersmith had his Christian successors in the worker in ivory and the marble masons.² Their love of craftsmanship was as high as their pagan rivals. In the same way the house of Titius Justus at Corinth and the *schola* of Tyrannus at Ephesus were doubtless decorated in the current style. In order to understand the representation of Christian subjects we may compare the parallel religions of Mithra and Isis. The Roman tolerance was always ready to welcome foreign worships, and on various grounds Vitruvius assigns the temples of Isis and Serapis to the neighbourhood of the quays.³ A fine bust of a Roman woman, Fundilia Rufa, probably of the early second

¹ IV. 3. 5; VIII. 6. 10.

² Marucchi, *Epigrafia Cristiana*, 290, 291, 293.

³ Book I. vii. 1.

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century, has the head-dress of Isis.¹ It was not until the second century that Mithra-worship became influential at Rome: by the end of the same century Commodus, who was represented by the sculptor as Heracles, appeared also as Mithra. The influence of Mithraism on Christian art is therefore negligible.

Christianity in its apocalyptic form could not make terms with the empire any more than Judaism with the Oriental despotism of Antiochus Epiphanes two centuries before. The burning of Rome, A.D. 64, brought this conflict to its first clear expression. Whatever the actual origin of the fire it is certain that Nero and the more fanatical Christians rejoiced at it. Nero found now the opportunity to rebuild his capital; an opportunity which was missed after the fire of London. His architects, who were also engineers, were Severus and Celer,² whom by their names we may presume to have been in the Roman tradition.

The odium which fell upon the Christians as guilty of incendiarism, and therefore enemies of the state, was resented by St. Luke, who seems to have published his two books soon after the fire in order, by an historical narrative, to reassure the new converts or the friends of the rising faith. The imperial government and troops appear as a just and almost kindly background to which the Christian is bound to adjust himself.³ We leave Paul at the end of *Acts* as a theological lecturer who had continued for two years receiving the general public into his own hired mansion (?) "*without let or hindrance.*" The fire of Rome, which brought the

¹ Nemi Collection, Castle Museum, Nottingham.

² Tac. *Ann.* XV, 42.

³ *Rom.* xiii. 1.

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martyrdom of SS. Peter and Paul, was attributed by the general judgment to the action of Nero. But externally it left very little mark upon the attitude of the government to the Church.

VII

Hence the artisans of Rome continued to work for Christian employers. It was even possible for members of the Flavian house to attach themselves to the Christian Church. The evidence of the catacombs supplements and interprets the historians. Flavius Clemens, like Polycarp later,¹ was put to death for "atheism" (*ἀθεϊσμός*), to be interpreted as Christianity.² Flavia Domitilla, whose relationship to Vespasian is doubtful, perhaps a niece, gave permission for the excavation of a Christian catacomb. Part of this was used for the burial of her relatives. The decoration of the vaulted roof of one of the apartments consists of a vine trailing with all the freedom of nature over the whole walls.³ The craftsman employs the current methods and exhibits the excellence of the best contemporary work. More than this, Christian painting so advanced that the best surviving examples of second-century painting are done by artists employed on Christian buildings. Vitruvius' demand for "imitations taken from reality"⁴ is satisfied by Christian art not only, as we have seen, in sculpture, but in landscape. After designing the garden, the architect calls upon the painter to portray it. A Roman turn is thus

¹ *Martyrdom*, 9.

² *Suet. Dom.* 15.

³ Northcote, *Roma Sotterranea*, 73.

⁴ *Book VII.* v. 3.

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given. Or shall we say that just as Egyptian gardens furnished models to Alexandria, so the Egyptian portrayal of gardens influenced the Alexandrian artists and thus came to Rome? In this case at least Strzygowski's emphasis on Oriental influences is justified.

With the garden the Roman palace is complete. The architect has taken all the instruments of splendour and worked them up into one significant scheme. The definition of Vitruvius is translated into its consequences. "The science of the architect depends upon many disciplines and various apprenticeships which are carried out in other arts."¹ But with the realism which characterises him, he not only recognises the amateur who builds for himself, but gives him encouragement, and suggests,² as one of the main purposes of the *de architectura*, that it should help the amateur. But the impulse to build is instinctive and carried to excess becomes almost morbid. The architectural passion was not confined to Nero: the Golden House as a palace of art was countered by the imagined splendour of the New Jerusalem, as the lines of old Babylon were repeated in the somewhat heavy contours of Ezekiel's vision. But when the ultimate significance of material things reached sublimity in the service of the Church, architecture passed by natural transitions to the achievement of Justinian. The Church of the Holy Wisdom at Byzantium after a millennium corresponded to the Parthenon.

Of this development the Book of Revelation is an anticipation and reveals its mysteries to the western

¹ Book I. i. 1.

² Book VI. pref. 7.

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craftsman.¹ Hence its appeal to the western mind over against the suspicion and rejection of the east. The craftsman might not understand the references to Jewish history. But he would understand the throne of the judge and the twenty-four assessors arranged round him circular fashion.² He would at once think of the great halls or basilicas³ in the palaces of wealthy citizens where an apse or semi-circular recess served as a tribunal. He would regard the door which was opened in heaven as the entrance to the hall from the end opposite to the throne, and the "sea of glass like crystal" as a mosaic pavement with its cubes of glass and marble.⁴ The furniture of the building is indicated in some detail—the candlesticks, the censers, the seals, the jewels.

But unfortunately the prophecy of *Revelation* was only realised in part. The later Byzantine and the Mediaeval architects omitted to plan their cities. Their water supplies⁵ were not brought on the lines described by Vitruvius in his eighth book. Their drainage⁶ was not as good even as that of old Jerusalem.⁷ The decline in the fine arts went along with the decline of the useful arts, of the sciences and of medicine. But the mechanical arts were sustained by the valuable and cherished recipes of Vitruvius.

The construction of organs, such as Vitruvius describes, came under the supervision of the archi-

¹ E.g. apse of S. Pudenziana, Rome.

² *Rev.* iv and v. ³ *Vitr.* Book VI. v. 2.

⁴ G. G. Scott, *English Church Architecture*, 29.

⁵ Cf. *Rev.* xxii. 1. ⁶ *Rev.* xxi. 27.

⁷ Neuburger, *Technical Arts and Sciences*, 438.

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tect, who was also a machinist: *machinator*. Severus and Celer, Nero's architects,¹ were in the Vitruvian tradition and doubtless superintended the construction of his organs. Nero "spent part of his day with organs, *organa hydraulica*, of a new and hitherto unknown kind."² They had several stops, up to eight at least.³ They were also supplemented by other instruments, such as the trombone,⁴ especially when they were used in the circus to mark the entrance of the gladiators.⁵ The organ was early used in the Church.⁶ It may be taken indeed that it followed the general law: until the downfall of Alexander Severus the surroundings of Christian worship included all the arts of the day. The organ especially was characteristic of the west and indeed was developed by the Church. Claudian speaks of its deep murmurs and melodies,⁷ and it gave an added beauty to the music of the cathedral of Milan. It is somewhat surprising that most of the current histories of Roman art ignore music altogether.

VIII

By a happy accident we are enabled to bring our survey to a close under the guidance of Sextus Julius Africanus. The fragment from Oxyrhynchus,⁸ in which he speaks of his directorship of the Pantheon library, gains added meaning when we realise that his interest in literature included the Christian future

¹ Tac. *Ann.* XV. 42.

² Suet. *Nero*, 41.

³ Book X. viii.

⁴ Baumeister, fig. 603.

⁵ Petronius, 36.

⁶ Tert. *Bapt.* 8.

⁷ *Manl. Theod. Cons.* 316-319.

⁸ *P. Oxy.* iii. 412. 8.

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as well as the past. The library¹ of the Roman palace, along with the basilica, passed into the service of the Church. Christian architecture, literature² and music were to hand on through the Middle Ages the corresponding elements of the classical tradition. But Vitruvius and Africanus were prized also for their military works, to which Vitruvius³ passes with a note of warning already quoted. "Inventions serve both to protect against danger and to satisfy the needs of safety." The brilliant civilisation of Rome was to live only so long as the Roman legions guarded the Rhine, the Danube and the Euphrates. The same secondary cause was also needed to protect the infancy of the Church.

¹ Book VI. iv.; v. 2.

² Kenyon, *Books and Readers in Greece and Rome*, 97, on papyrus codices.

³ Book X. x. 1.

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The *Anthology*¹ (not yet published) of William of Malmesbury, Harl. 3969, fol. 8 v., begins a series of extracts from Vitruvius. The spelling *Victruvius* indicates that they were transcribed from a MS. written at St. Augustine's Abbey, Canterbury, Vol. I. *intro.* xix. The interest of William was mainly aroused by the military engineering of Book X., and by the mechanical devices described in both Book IX. and Book X. To the latter topic he makes a summary reference: *omittantur illa quae sunt quidem ad audiendum grata sed ad intellegendum gravia, quolesbicus (i.e. Ctesibius) hydraulica organa invenit, quonam ut curru sedens intelligas quot milia vel terrae vel aquae peregristi, quo modo Archimedes furtum illum reprehendit qui argentū aureae coronae iunxerit.* William obviously regarded the *de architectura* as a practical manual. It is probable that the builders of the Norman church at Malmesbury, with its fine South Porch (still standing), followed some of its precepts.

A century later Vincent of Beauvais, c. 1250, incorporated into his *Speculum* material taken from Vitruvius. His MS. of Vitruvius was derived from S or G, as is shown by his quoting the interpolation

¹ This reference is due to Dr. M. R. James.

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of *S* in Book I. i. 1: *cuius iudicio probantur omnia*. He uses the mediaeval Latin *architectura* for *architectura*, implying "architector" once current in English with its feminine "architectress," a term which might well be revived. Like William of Malmesbury, he is occupied with the practical application of Vitruvius' text-book to mechanics and to building construction and neglects the description of the orders.

We are thus prepared for the fragments of a late MS. of Vitruvius¹ to be found in the Public Record Office to which Mr. Charles Johnson drew my attention: Chancery Bundle 34, File 11, Folios 35-40.

NOTE ON THE SPELLING OF *H*²

The Latin text of this edition is taken from the Harleian MS. 2767. The spelling is therefore not uniform; I have included all the variations which seem to be legitimate. In the *Monumentum Ancyranum* along with more usual forms *apsenti* and *inmisso* occur: *conlegio* with *collega* in the same sentence. This precedent is followed by Munro in his *Lucretius* and Housman in his *Manilius*. Munro has *committere*, v. 782, and *inmissis* below, v. 787. Housman has *inmota*, v. 428, and *immotis*, i. 632. He prints *delabsa* and quotes Ribbeck for *labsus* in thirty places of the

¹ I reported this discovery at greater length, *Journal of Royal Institute of British Architects*, April 1931.

² The circumstance that all extant MSS. of Vitruvius descend from *H*—the case of *G* is dealt with in the next section—makes it possible to follow throughout—subject to the emendations recorded—the spellings current before the Carolingian revision and the changes introduced after the revision.

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best MSS. of Virgil, *ad* v. 732. He gives the nom. plur. of the 3rd decl. in *is*, i. 601, v. 222, *etc.*, the acc. plur. in *is* frequently. There are traces of *quoquere* for *coquere* in the best MSS. of Manilius, v. 533 and 683: I have admitted *quoquendum* to the text, V. ix. 8.

I hesitated to write, with *H*, *scribsi scribtum* and the corresponding forms even with the support of the Amiatinus vulgate. But *praescribta* is once found in Lucretius, once also *elabsa*, Munro *ad* vi. 92. I have recorded both *oportunus* and *opportunus*; *obportunus* never occurs.

There is a special reason why *H* should be found thus faithful to older forms. So far as *H* follows the form of specifications, it is of a quasi-legal character. *Lex* represents "specification" twice in Book I. i. 10 and again in Book VII. v. 8. This fact, in my opinion, entirely precludes the extensive recasting of the order of the text proposed by Krohn in his review of my first volume, *Phil. Woch.*, Dec. 24, 1932. Compared with most technical treatises, the ten books on Architecture are much above the average in order and clearness.

THE INTERPOLATIONS IN G

There are some fifty cases in which *G* offers readings which are not represented in *H* by corresponding phrases or single words. There are also many cases in which *G* makes useful and obvious corrections in *H*, and not a few corrections which are less obvious and yet convincing. A brief review of these will throw light upon the method of the scribe. They all are made in the spirit of a Ciceronian, as

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Ciceronianism was understood after Alcuin. The least valuable corrections are those which assimilate the spelling of *H* to later forms, e.g. *Volturnus* to *Vulturnus*, *formonsos* to *formosos*, nor is there any reason to be grateful for the correction of *imperii* to *imperio* after *potiretur*, VI. i. 11, especially when *G* has *rerum potiretur*, VII. pref. 17. He shows acquaintance with the subject-matter when he corrects *aliis* to *alis*, VI. iii. 4, but in the main his services are grammatical, as when he substitutes *indignans* for *indignus*, VII. pref. 8. He is a better "grammarian" than the scribe of *H* but he is not so faithful. This formula of the copyist is abundantly illustrated in the changes which were made in the Greek text of the N.T.: for the Vulgate we can trace the similar method of Alcuin and his school in dealing with the Amiatinus. The critical notes of Wordsworth and White show the Vallicellanus—the best example of Alcuin's recension—differing from the Amiatinus in the same way as *G* differs from *H*, but not to the same extent. The reason for this difference is the greater difficulty of Vitruvius.

Apart from the introductions to the ten books and from the historical parentheses, the language of Vitruvius is like that of a specification: technical and *elliptical*. The craftsman writing for craftsmen assumes a background of knowledge which is only in part shared by the layman. As Vitruvius himself says: "only those who are experienced in his subject-matter, will find his descriptions easy to understand," X. viii. 6. For the most part, indeed, the interpolations of *G* do not add to our knowledge and are harmless. I have inserted for information the longer interpolations of *G* in the second five

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books without translating them. Two of them are obviously caused by the omission of *sunt*: VII. pref. 14 and VII. v. 2. Two are merely duplications of epithets: VIII. i. 2, and IX. pref. 15. IX. ii. 2 is a gloss to explain the reference to the moon.

But two interpolations have seriously corrupted the text. The interpolation of *G*, III. v. 2 destroyed *H*'s description of the Attic base as a roundel above and a sweeping scotia (with its fillets) below. Attic examples of such a base are found in the Temple of Apollo by Ictinus at Bassae and the Nike Temple at Athens. The translation of *H* runs: "taking the plinth away, the remainder is to be divided into four parts; the top part is to be the torus, the remainder is to be the scotia with its fillets." There is an interesting parallel in our Norman, or, as the French more correctly say, Roman architecture. The Norman bases in Canterbury Cathedral exhibit several cases of the roundel and scotia according with the formula of *H*. The tradition of this MS. was specially guarded in the adjoining library of St. Augustine's Abbey, Vol. I. *intro.* xix. The other serious interpolation of *G*, Book III. iii. 7, is both inaccurate and superfluous.

The faults as well as the excellences of *G* are due to its origin. They characterise the revision which all or nearly all Latin MSS. received, in the interest of grammar, along with the revision of all Church books decreed in 789. It is reasonably certain, therefore, that *G* represents the form which Vitruvius took after a similar revision. By the courtesy of the editors of the *Classical Review* a full discussion of the interpolations of *G* and a defence of the primacy of

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VITRUVIUS
ON ARCHITECTURE
BOOKS VI—X

VITRUVII
DE ARCHITECTURA
LIBER SEXTUS

- 1 ARISTIPPUS philosophus Socraticus, naufragio cum eiectus ad Rhodiensium litus animadvertisset geometrica schemata descripta, exclamavisse ad comites ita dicitur: 'bene speremus! hominum enim vestigia video.' Statimque in oppidum Rhodum¹ contendit et recta² gymnasium devenit, ibique de philosophia disputans muneribus est donatus, ut non tantum se ornaret, sed etiam eis, qui una fuerunt, et vestitum et cetera, quae opus essent ad victum, praestaret. Cum autem eius comites in patriam reverti voluissent interrogarentque eum, quidnam vellet domum renuntiari, tunc ita mandavit dicere: eiusmodi possessiones et viatica liberis oportere parari, quae etiam e naufragio una possent enare.³
- 2 Namque ea vera praesidia sunt vitae, quibus neque fortunae tempestas iniqua neque publicarum rerum mutatio neque belli vastatio potest nocere. Non minus eam sententiam augendo Theophrastus, hor-

¹ Rodum *H.* ² recta *H* : recte *G*, recta via *S*.

³ enare *Gr.* : enarrare *H*.

¹ Aristippus of Cyrene taught that pleasure was the end of conduct.

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BOOK VI

PREFACE

1. THE philosopher Aristippus,¹ a follower of Socrates, was shipwrecked on the coast at Rhodes, and observing geometrical diagrams drawn upon the sand, he is said to have shouted to his companions: "There are good hopes for us; for I see human footsteps!" Forthwith he made for the city of Rhodes and came straight to the gymnasium. There he disputed on philosophical topics and was so richly rewarded that he not only fitted himself out, but supplied his companions with clothing and other necessities of life. When they wanted to go home, and asked him what message he wished them to take, he enjoined on them to say, that men should provide for their children wealth and travelling equipment of such a kind, that, even after shipwreck, it can swim to land along with its owners.

2. For those are the true safeguards of life which are immune from the stormy injustice of Fortune, the changes of politics and the ravages of war. Theophrastus,² indeed, carries that opinion further,

² Theophrastus, the follower and successor of Aristotle.

tando doctos potius esse quam pecuniae confidentes, ita ponit: doctum ex omnibus solum neque in alienis locis peregrinum neque amissis familiaribus et necessariis inopem amicorum, sed in omni civitate esse civem difficilesque fortunae sine timore posse despiciere casus; at ¹ qui non doctrinarum sed felicitatis praesidiis putaret se esse vallatum, labidis itineribus vadentem non stabili ² sed infirma conflictari vita.

- 3 Epicurus vero non dissimiliter ait: ³ pauca sapientibus fortunam tribuere, quae autem maxima et necessaria sunt, animi mentisque cogitationibus gubernari. Haec ita etiam plures philosophi dixerunt. Non minus poetae, qui antiquas comoedias graece scripserunt, easdem sententias versibus in scaena pronuntiaverunt, ut Crates, ⁴ Chionides, Aristophanes, maxime etiam cum his Alexis, qui Athenienses ait oportere ideo laudari, quod omnium Graecorum leges cogunt parentes <ali> ⁵ a liberis, Atheniensium non omnes nisi eos, qui liberos artibus erudissent. Omnia enim munera fortunae cum dantur, ab ea faciliter adimuntur; disciplinae vero coniunctae cum animis nullo tempore deficiunt, sed permanent
- 4 stabiliter ad summum exitum vitae. Itaque ego maximas infinitasque parentibus ago atque habeo gratias, quod Atheniensium legem probantes me arte erudiendum curaverunt, et ea, quae non potest

¹ ad qui *H.* ² stabilis *H.* ³ ait *S*: aut. *H.*

⁴ Crates *Bondam*: eucrates, *H.* ⁵ add. *rec.*

¹ Epicurus refined on the morals of Aristippus, and combined them with the atomic philosophy of nature, *Diog. X. 144.*

² Crates introduced systematic plots into Greek comedy, *Arist. Poet. 5.*

BOOK VI. PREFACE

and exhorts us to trust in learning rather than wealth. He lays down this principle: that, alone of all mankind, the scholar is no stranger in foreign lands; after losing kinsmen and intimates he still finds friends; he is a citizen in every state, and fearlessly despises the awkward chances of fortune; on the other hand, the man who thinks himself fortified and guarded by good fortune rather than by education, steps along slippery paths and struggles with a life unstable and insecure.

3. Epicurus,¹ too, says in a similar strain: the gifts of fortune to the wise are few but great and indispensable, namely, that they be governed by the judgments of the mind and heart. So also most philosophers have spoken. The poets too of old, who wrote Greek comedies, delivered on the stage the same opinions in their verses: Crates,² for example, Chionides,³ Aristophanes,⁴ but, most of all, Alexis,⁵ who says that the Athenians deserve praise because the laws of all the other Greeks compel children to maintain their parents, whereas the laws of Athens only applied to those parents who had their children taught a trade. For all gifts of Fortune, as they are bestowed by her, so are they easily withdrawn; but when training is conjoined with mental power, it never fails, but abides secure to the final issue of life. 4. Therefore, I feel and return great and unbounded gratitude to my parents, because they approved the law of Athens and had me trained in a calling, wherein one cannot pass

¹ One of the earliest Greek writers of comedy.

² Aristoph. *Frag.* 540 mentions Eucrates. *Cf. H. supra.*

³ Writer of middle comedy; his plays were translated into Latin.

esse probata sine litteraturae encycloque doctrinarum omnium disciplina. Cum ergo et parentium cura et praeceptorum doctrinis auctas haberem copias disciplinarum, philologis et philotechninis rebus commentariorumque scribendis me delectans eas possessiones animo paravi, e quibus haec est fructuum summa: nullas¹ plus habendi esse necessitates eamque esse proprietatem, divitiarum maxime, nihil desiderare. Sed forte nonnulli haec levia iudicantes putant eo² esse sapientes, qui pecunia sunt copiosi. Itaque plerique ad id propositum contententes audacia adhibita cum divitiis etiam notitiam sunt consecuti.

- 5 Ego autem, Caesar, non ad pecuniam parandam ex arte dedi studium, sed potius tenuitatem cum bona fama quam abundantiam cum infamia sequendam probavi. Ideo notities parum est adsecuta. Sed tamen his voluminibus editis, ut spero, etiam posteris ero notus. Neque est mirandum, quid ita pluribus sim ignotus. Ceteri architecti rogant et ambigunt, ut architectent;³ mihi autem a praeceptoribus est traditum: rogatum, non rogantem oportere suscipere curam, quod ingenuus color movetur pudore petendo rem suspiciosam. Nam beneficium dantes, non accipientes ambiuntur. Quid enim putemus suspicari, qui rogetur de patrimonio sumptus faciendos committere gratiae pe-

¹ nullas *G*: nulla *H*.

² putantes eo esse *H*.

³ archititent *H*.

¹ *orbis doctrinae*, Quint. I. 10. 1. 'The unity of the subjects included in a general education,' cf. Book I. 1. 12.

BOOK VI. PREFACE

muster without knowledge of letters, and of the 'liberal arts.'¹ When therefore both the care of my parents and the instruction of my teachers had increased my stock of knowledge, I found delight in literary and technical matters and in the works written upon them, thus acquiring mental possessions of which this is the total profit: that there is no necessity of getting more and more, and that property consists in requiring nothing, least of all, riches. But some perhaps make light of these considerations and think that those who are wealthy are thereby wise. Therefore many persons, striving to that end, combine wealth with assurance, and make the further gain of celebrity.

5. But, your Highness, I have not studied with the view of making money by my profession; rather have I held that a slight fortune with good repute is to be pursued more than abounding wealth accompanied by disgrace. Thus little celebrity has come my way. Yet by publishing these volumes,² my name will reach, I hope, to after times. Nor is there cause for wonder why I am unknown to the general. Other architects beg and wrangle to obtain commissions; but I follow a rule laid down by my masters: not to seek employment but to be sought out; since an open countenance³ changes for shame when a request is made of a doubtful character. For the giver of a favour is courted, not the receiver. For what do we think will be suspected by a man who is asked to entrust expenditure at his own cost to the pleasure of the petitioner? Will he not

¹ The books *de architectura* were probably published at various times.

² *ingenui voltus puer ingenuique pudoris*, Juv. XI. 154. Cf. Prop. I. iv. 13.

tentis, nisi praedae compendiique eius causa iudicet
 6 faciendum? Itaque maiores primum a genere probatis operam tradebant architectis, deinde quaerebant, si honeste essent educati, ingenuo pudori, non audaciae protervitatibus permittendum iudicantes. Ipsi autem artifices non erudiebant nisi suos liberos aut cognatos et eos viros bonos instituebant, quibus tantarum rerum fidei pecuniae sine dubitatione permitterentur.

Cum autem animadverto ab indoctis et inperitis tantae disciplinae magnitudinem iactari et ab is, qui non modo architecturae sed omnino ne fabricae quidem notitiam habent, non possum non laudare patres familiarum eos, qui litteraturae fiducia confirmati per se aedificantes ita iudicant: si inperitis sit committendum, ipsos potius digniores esse ad suam voluntatem quam ad alienam pecuniae consumere summam.
 7 Itaque nemo artem ullam aliam conatur domi facere, uti sutrinam, fullonicam aut ex ceteris, quae sunt faciliores, nisi architecturam, ideo quod, qui profitentur, non arte vera sed falso nominantur architecti. Quas ob res corpus architecturae rationesque eius putavi diligentissime conscribendas, opinans in munus omnibus gentibus non ingratum futurum. Igitur, quoniam in quinto de opportunitate communium operum perscripsi, in hoc volumine privatorum aedificiorum ratiocinationes et commensus symmetriarum explicabo.

¹ The Roman ideal of a gentleman, *ingenuus*, included modesty, and was nearer to the Christian ideal than that of the Stoic, which, in some cases, leaned to a Cynical disregard of decency.

BOOK VI. PREFACE

judge that it is to be done for the profit and advantage of the other man? 6. Therefore our forefathers used to entrust commissions to architects of approved descent in the first place; in the second place they inquired if they were well brought up, considering that they should employ men with a sense of honour,¹ rather than persons of a bold and insolent turn. For the craftsmen themselves trained only their own children and kindred, and those apprentices who were so worthy, that large sums could be entrusted without hesitation to their loyalty.

But while I observe that an art of such magnificence is professed by persons without training and experience, by those who are ignorant not only of architecture but even of construction, I cannot refrain from praising those owners of estates who, fortified by confidence in their own erudition, build for themselves, judging that if inexperienced persons are to be employed, they themselves are entitled to spend their own capital to their own liking rather than to that of anyone else. For no one attempts to practise any other calling at home, such as shoe-making or fulling or any other easy occupation, with the one exception of architecture, because persons who profess it are falsely called architects in the absence of a genuine training. And so I considered it a duty to compile with care a system and method of architecture, imagining it would serve a purpose generally acceptable. Therefore since in the fifth book I dealt with the suitable provision of public buildings, in this book I will explain the calculations involved in private buildings and the adjustment of their proportions.

VITRUVIUS

I

- 1 HAEC autem ita erunt recte disposita, si primo animadversum fuerit, quibus regionibus aut quibus inclinationibus mundi constituentur. Namque aliter Aegypto, aliter Hispania, non eodem modo Ponto, dissimiliter Romae, item ceteris terrarum et regionum proprietatibus oportere videntur constitui genera aedificiorum, quod alia parte solis cursu premitur tellus, alia longe ab eo distat, alia per medium temperatur. Igitur, uti constitutio mundi ad terrae spatium in inclinatione signiferi circuli et solis cursu disparibus qualitatibus naturaliter est conlocata, ad eundem modum etiam ad regionum rationes caelique varietates videntur aedificiorum debere dirigi con-
- 2 locationes. Sub septentrione aedificia testudinata et maxime conclusa et non patentia, sed conversa ad calidas partes oportere fieri videntur. Contra autem sub inpetu solis meridianis regionibus, quod premuntur a calore, patentiora conversaque ad septentrionem et aquilonem sunt faciunda. Ita, quod ultra natura laedit, arte erit emendandum. Item reliquis regionibus ad eundem modum temperari, quemadmodum caelum est ad inclinationem mundi conlocatum.
- 3 Haec autem ex natura rerum sunt animadvertenda et considerata atque etiam ex membris corporibusque gentium observanda. Namque sol quibus locis mediocriter profundit vapores, in his conservat

¹ *signifer orbis*, Lucr. v. 691.

² See diagram of winds, Vol. I. Pl. A.

³ *illud quod cecidit forte, id arte ut corrigas*. Ter. Ad. IV. 7.

CHAPTER I

THE INFLUENCE OF CLIMATE UPON ARCHITECTURE

1. Now we shall proceed aright herein if first we observe in what regions or latitudes of the world, our work is placed. For the style of building ought manifestly to be different in Egypt and Spain, in Pontus and Rome, and in countries and regions of various characters. For in one part the earth is oppressed by the sun in its course; in another part, the earth is far removed from it; in another, it is affected by it at a moderate distance. Therefore since, in the sun's course through the inclination of the zodiac,¹ the relation of the heavens to the earth is arranged by nature with varying effects, it appears that in like manner the arrangement of buildings should be guided by the kind of locality and the changes of climate. 2. Towards the north, buildings, I think, should be vaulted, thoroughly shut in rather than exposed, and with an aspect to the warmer quarter. On the other hand, where the sun is violent in the southern regions because they are oppressed by the heat, buildings should be open to the air with a northern, or north-eastern,² aspect. Thus we may remedy by art the harm that comes by chance.³ In other regions also, buildings are to be similarly adjusted to suit the relation of climate to latitude.

3. Now these things are to be observed and weighed in the light of Nature, and further to be tested by the figure and physique of different peoples. For in those regions where the sun pours forth a moderate heat, he keeps the body duly tem-

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corpora temperata; quaeque proxime currendo deflagrant, eripit exurendo temperaturam umoris; contra vero refrigeratis regionibus, quod absunt a meridie longe, non exhauritur a coloribus umor, sed ex caelo roscidus aer in corpora fundens¹ umorem efficit ampliores corporaturas vocisque sonitus graviores. Ex eo quoque, <quae>² sub septentrionibus nutriuntur gentes, inmanibus corporibus, candidis coloribus, directo capillo et rufo, oculis caesis, sanguine multo ab umoris plenitate caelique re-

4 frigerationibus sunt conformati; qui autem sunt proximi ad axem meridianum subiectique solis cursui, brevioribus corporibus, colore fusco, crispo capillo, oculis nigris, cruribus validis, sanguine exiguo solis impetu perficiuntur. Itaque etiam propter sanguinis exiguitatem timidiores sunt ferro resistere, sed ardores ac febres subferunt sine timore,³ quod nutrita sunt eorum membra cum fervore; itaque corpora, quae nascuntur sub septentrione, a febre sunt timidiora et inbecilla, sanguinis autem abundantia ferro resistunt sine timore.

5 Non minus sonus vocis in generibus gentium dispares et varias habet qualitates, ideo quod terminatio orientis et occidentis circa terrae librationem, qua dividitur pars superior et inferior mundi, habere videtur libratam naturali modo circumitionem, quam etiam mathematici *orizonta* dicunt. Igitur cum id habemus certum animo sustinentes, ab labro, quod est in regione septentrionali, linea traiecta ad id, quod est supra meridianum axem, ab eoque altera obliqua⁴ in altitudinem ad summum cardinem, qui

¹ fundans H.

² add. Ro.

³ tumore H.

⁴ altera obliqua Laet: -am bis H.

¹ I.e. the bounding-line.

pered; where he comes near and the earth scorches, he burns out and removes the moisture; whereas in the cold regions, because they are far distant from the south, the moisture is not drawn out from their complexions, but the dewy air from the sky pours moisture into the body, enlarges the physique and deepens the voice. Hence, also, the races of the north receive nourishment, and are characterised by tall stature, fair complexion, straight red hair, blue eyes, fullness of blood, owing to the abundance of moisture and the cool climate. 4. Those, however, who are nearest to the southern climes and under the sun's orbit, owing to his violence, have a smaller stature, dark complexion, curly hair, black eyes, strong legs, and thinness of blood. Therefore, also, because of their thin blood, they fear to resist the sword, but endure heat and fever without fear, because their limbs are nourished by heat. Those persons who are born under a northern sky, are weak and more timid in face of fever, but fearlessly resist the sword owing to their fullness of blood.

5. In like manner the sound of the voice has varied qualities which differ with different races. And the reason is that the limits between east and west around the level of the earth (where the upper and lower part of the world is divided) seem to have the circumference naturally levelled, and this the astronomers name the *horizon*.¹ Therefore when we have kept this fixed in our mind, let a line be drawn from the margin which is in the north to the margin which is towards the south, and from the latter a second line ² inclined upwards to the pole which is

¹ The lines of longitude do not follow the curvature of the earth, but are assumed to be drawn in a straight line from the equator to the north pole of the heavens.

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est post stellas septentrionum, sine dubitatione animadvertemus ex eo esse schema ¹ trigonii mundo, uti organi, quam *sambucen* Graeci dicunt.

6 Itaque quod est spatium proximum imo cardini ² ab axis linea in meridianis finibus, sub eo loco quae sunt nationes, propter brevitatem altitudinis ad mundum sonitum vocis faciunt tenuem et acutissimum, uti in organo chorda, quae est proxima angulo. Secundum eam autem reliquae ad mediam Graeciam remissionibus efficiunt in nationibus sonorum cantiones.³ Item a medio in ordinem crescendo ad extremos septentriones sub altitudines caeli nationum spiritus sonitibus ⁴ gravioribus a natura rerum exprimuntur. Ita videtur mundi conceptio tota propter inclinationem consonantissime per solis temperaturam ad harmoniam esse composita.

7 Igitur quae nationes sunt inter axis meridiani cardinem ab septentrionalis medio positae, uti in diagrammate⁵ musico medianae vocis habent sonitum in sermone; quaeque progredientibus ad septentrionem sunt nationes, quod altiores habent distantias mundi,⁶ spiritus vocis habentes umore⁷ repulsos ad hypatas et proslambanomenos,⁸ a natura rerum sonitu graviore coguntur uti; eadem ratione medio progredientibus ad meridiem gentes paranetarum ⁸ <netarum>⁹que acutissimam sonitus vocis perficiunt tenuitatem. Hoc autem verum esse, ex umidis naturae locis graviora fieri et ex fervidis acutiora,

¹ scaena H. ² cardini rec: -ne H.

³ cansiones H: cantiones h.

⁴ sonitibus rec: sonitus H.

⁵ india grāmata H.

⁶ mundi Kr: admundi (cum ad add.) H.

⁷ umore rec: -rem H.

⁸ acc. pl.

⁹ add. Fea.

¹ A kind of harp: a triangular stringed instrument.

behind the stars of the Great Bear. From this we shall undoubtedly perceive that the world has a triangular lay-out, like the sackbut which the Greeks call *sambucê*.¹

6. Therefore if we take the region in the south which is nearest to the lowest point, the nations which are under that quarter, have vocal sounds which are thin and very shrill, because of the small height towards the limit of the universe, like the string of the instrument which is next to the angle. Next to this, the other strings so far as Greece which is in the middle, produce by their relaxation, the pitch of the voice for each nation. Further, rising regularly from the middle to the height in the furthest north, the national pitch is naturally produced with deeper tones. Thus the whole system of the world because of the slope from south to north seems to be most agreeably adjusted to harmony by the temperature of the sun.

7. Therefore the nations which are placed in the middle between the equator and the north pole have in conversation a middle accent corresponding to the musical diagram; the nations as we move northwards, because they have a greater distance between them and the universe, have a vocal accent driven by greater moisture to the *hypatae*² and *proslambanomenoe*² and are compelled by Nature to use a deeper voice; in the same way as we progress from the middle to the south, the nations have a very shrill accent corresponding to the *paranetae*³ and *netae*.³ 8. We can observe by experiment that heavier and deeper effects arise in damp places, and lighter and shriller

¹ The lowest notes : see Vol. I. Pl. F.

² The highest notes : *ib.*

licet ita experiendo animadvertere. Calices duo in una fornace aequae cocti aequoque pondere ad crepitumque uno sonitu sumantur. Ex his unus in aquam demittatur, postea ex aqua eximatur; tunc utrique tangantur. Cum enim ita factum fuerit, largiter inter eos sonitus discrepabit, aequoque pondere non poterunt esse. Ita et hominum corpora uno genere figurationis et una mundi coniunctione concepta alia propter regionis ardorem acutum spiritum aeris exprimunt tactu, alia propter umoris abundantiam gravissimas effundunt sonorum qualitates.

9 Item propter tenuitatem caeli meridianae nationes ex acuta fervore mente expeditius celeriusque moventur ad consiliorum cogitationes; septentrionalis¹ autem gentes infusae crassitudine caeli, propter obstantiam aeris umore refrigeratae stupentes habent mentes. Hoc autem ita esse a serpentibus² licet aspicere, quae, per calorem cum exhaustam habent umoris refrigerationem, tunc acerrime moventur, per brumalia autem et hiberna tempora ab mutatione caeli refrigerata, inmota sunt stupore. Ita non est mirandum, si acutiores efficit calidus aer hominum mentes, refrigeratus autem contra tardiores.

10 Cum sint autem meridianae nationes animis acutissimis infinitaque sollertia consiliorum, simul ad fortitudinem ingrediuntur, ibi succumbunt, quod habent exuctas ab sole animorum virtutes; qui vero refrigeratis nascuntur regionibus, ad armorum vehementiam paratiores sunt; magnis virtutibus sunt sine timore, sed tarditate animi sine considerantia inruentes sine sollertia suis consiliis refragantur.

¹ *nom. pl.*

² *nom. pl. serpentia, Vulg. Act. X. 12.*

effects in hot places. Let two cups be taken equally burnt in one kiln of equal weight, and of the same sound when struck. Of these let one be plunged into water and then taken out of the water. Then let both be struck. When this is done, there will be a considerable difference of sound between them, and they will differ in weight. So also the bodies of human beings born of the same shape and under the same conjunction of the heavens will vary: some on account of the heat of the region have, under its influence, an acute or shrill accent, others on account of the abundant moisture, pour forth the heaviest or deepest utterances.

9. Southern nations also, owing to the rarity of the atmosphere, with minds rendered acute by the heat, are more readily and swiftly moved to the imagination of expedients; but northern peoples steeped in a thick climate amid reluctant air, are chilled by the damp, and have sluggish minds. We can observe this in the case of snakes: they move quickest when the heat has drawn away the damp with its chilling effect; but in the rainy and wintry seasons they are chilled by the change of climate, and are sluggish and motionless. Hence we need not wonder if warm air renders the human mind more acute, and a cool air impedes.

10. Now while the southern peoples are of acute intelligence and infinite resource, they give way when courage is demanded because their strength is drained away by the sun; but those who are born in colder regions, by their fearless courage are better equipped for the clash of arms, yet by their slowness of mind they rush on without reflection, and through lack of tactics are balked of their purpose. Since,

- Cum ergo haec ita sint ab natura rerum in mundo conlocata et omnes nationes inmoderatis mixtionibus disparatae, vero inter spatium totius orbis terrarum regionisque medio mundi populus Romanus
- 11 possidet fines. Namque temperatissimae ad utramque partem et corporum membris animorumque vigoribus pro fortitudine sunt in Italia gentes. Quemadmodum enim Iovis stella inter Martis ferventissimam et Saturni frigidissimam media currens temperatur, eadem ratione Italia inter septentrionalem meridianamque ab utraque¹ parte mixtionibus temperatas et invictas habet laudes. Itaque consiliis refringit barbarorum virtutes, forti manu² meridianorum cogitationes. Ita divina mens civitatem populi Romani egregiam temperatamque regionem conlocavit, uti orbis terrarum imperii³ potiretur.
- 12 Quodsi ita est, uti dissimiles regiones ab inclinationibus caeli variis generibus sint comparatae, ut etiam naturae gentium disparibus animis et corporum figuris qualitatibusque nascerentur, non dubitemus aedificiorum quoque rationes ad nationum gentiumque proprietates apte distribuere, cum habeamus ab ipsa rerum natura sollertem et expeditam monstrationem.

Quoad potui summa ratione proprietates locorum ab natura rerum dispositas animadvertere, exposui, et, quemadmodum ad solis cursum et inclinationes caeli oporteat ad gentium figuras constituere aedifi-

¹ utroque *H.* ² (manu) consiliis *H* (*del. Joc.*).

³ imperii *H* : imperio *G.*

therefore, the disposition of the world is such by Nature, and all other nations differ by their unbalanced temperament,¹ it is in the true mean within the space of all the world and the regions of the earth, that the Roman people holds its territories. 11. For in Italy the inhabitants are exactly tempered in either direction, both in the structure of the body, and by their strength of mind in the matter of endurance and courage. For just as the planet Jupiter is tempered by running in the middle between the heat of Mars and the cold of Saturn, in the same manner Italy presents good qualities² which are tempered by admixture from either side both north and south, and are consequently unsurpassed. And so, by its policy, it curbs the courage of the northern barbarians; by its strength, the imaginative south. Thus the divine mind has allotted to the Roman state an excellent and temperate region in order to rule the world.

12. But if regions differing in climate are assigned to different nations so that the natures of peoples that arise, should vary in mind, and in shape and quality of body, we shall not hesitate to arrange the methods of our buildings also, to suit the characters of nations and peoples, since from Nature herself we have skilled and ready guidance.

As far as I could observe systematically regional characteristics ordained by Nature, I have expounded them, and have said how, in reference to the sun's course and the differences of climate, we ought to determine the style of our house so as to suit the

¹ 'Temperament' corresponds to chemical combination, but applies to physiological and mental combination as well.

² *Laudes*, 'grounds of praise.'

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ciorum qualitates, dixi; itaque nunc singulorum generum in aedificiis commensus symmetriarum et universos et separatos breviter explicabo.

II

- 1 NULLA architecto maior cura esse debet, nisi uti proportionibus ratae partis habeant aedificia rationum exactiones. Cum ergo constituta symmetriarum ratio fuerit et commensus ratiocinationibus explicati, tum etiam acuminis est proprium providere ad naturam loci aut usum aut speciem, adiectionibus temperaturas efficere, cum de symmetria sit detractum aut adiectum, uti id videatur recte esse formatum in aspectuque nihil desideretur.
- 2 Alia enim ad manum species¹ videtur, alia in excelso, non eadem in concluso, dissimilis in aperto, in quibus magni iudicii est opera, quid tandem sit faciundum. Non enim veros videtur habere visus effectus, sed fallitur saepius iudicio ab eo mens. Quemadmodum etiam in scenis² pictis videntur columnarum proiecturae, mutulorum ecphorae,³ signorum figurae prominentes, cum sit tabula sine dubio ad regulam plana. Similiter in navibus remi, cum sint sub aqua directi, tamen oculis infracti videntur; et quatenus eorum partes tangunt summam planitiem liquoris,⁴ apparent, uti sunt, directi,

¹ species esse v. *G*: species se v. *H*.

² scenis *G*: caenis *H*, Plin. *N.H.* XII. 10.

³ ecphorę *G*: esphorae *H*.

⁴ liquoris *G*: liquores *H*.

¹ Optical adjustments, Book III. iii. 13.

² Architectural style of painting, 80-30 B.C.

needs of the body. It remains now to explain in brief, both generally and particularly, the symmetrical adjustment of the several methods of building.

CHAPTER II

PROPORTION IN BUILDING

1. THE architect's greatest care must be that his buildings should have their design determined by the proportions of a fixed unit. When therefore account has been taken of the symmetries of the design and the dimensions have been worked out by calculation, it is then the business of his skill to have regard to the nature of the site, either for use or beauty, to produce a proper balance by adjustment, adding or subtracting from the symmetry of the design, so that it may seem to be rightly planned and the elevation¹ may lack nothing.

2. For one kind of appearance is seen near at hand; another, in a lofty building; yet another in a confined site; a different one in an open site. And it is the business of a fine judgment to determine exactly what is to be done in these cases. For the eyes do not appear to bring accurate results, but the judgment is often deceived by it: just as when, in the paintings of stages, there seem to be projecting columns, corbelled mutules, outstanding shapes of statues, although the picture is undoubtedly vertical and regular.² Similarly in the case of ships, when the oars are put straight in the water, yet to the eyes they seem broken: until their parts touch the topmost level of the liquid, they appear straight, as indeed they are, but when

- cum vero sub aqua sunt dimissi, per naturae per-
 lucidam raritatem remittunt enatantes ab suis cor-
 poribus fluentes imagines ad summam aquae plani-
 tiem, atque eae ibi commotae efficere videntur
- 3 infractum remorum oculis aspectum. Hoc autem
 sive simulacrorum impulsu seu radiorum ex oculis
 effusionibus, uti physicis placet, videmus, utramque
 rationem videtur ita esse, uti falsa iudicia oculorum
- 4 habeat aspectus. Cum ergo, quae sunt vera, falsa
 videantur et nonnulla aliter quam sunt oculis pro-
 bentur, non puto oportere esse dubium, quin¹ ad
 locorum naturas aut necessitates detractationes aut
 adiectiones fieri debeant, sed ita, uti nihil in his
 operibus desideretur. Haec autem etiam ingenio-
 rum acuminibus, non solum doctrinis efficiuntur.
- 5 Igitur statuenda est primum ratio symmetriarum,
 a qua sumatur sine dubitatione commutatio, deinde
 explicetur operis futuri locorum unum spatium longi-
 tudinis, cuius semel constituta fuerit magnitudo,
 sequatur eam proportionis ad decorem apparatus,
 uti non sit considerantibus aspectus eurythmiae
 dubius. De qua, quibus rationibus efficiatur, est
 mihi pronuntiandum, primumque de cavis aedium,
 uti fieri debeant, dicam.

¹ quin *G*: quam *H*.

they are let down under the water, owing to the transparent thinness of the element, they send back images¹ flowing from their substance, which float at the topmost level of the water, and being there disturbed, they seem to the eyes to produce a broken appearance of the oars. 3. Now whether we see by the impression of images upon the eye, or by the effusion of rays from the eyes, as the natural philosophers teach us, both explanations suggest that the vision of the eyes gives false judgments. 4. Since, therefore, what is real seems false, and some things are approved by the eyes as other than they really are, I do not think it should be doubtful that we ought to add or subtract, as needed by the nature or requirements of our sites: but this is done by native skill and not by rule alone.

5. We must therefore first determine the method of the symmetries, from which these modifications are to be correctly deduced. Then the unit² of length for the site of the future work is to be set forth. When the magnitude of this is once determined, there will follow upon it the adjustment of the proportions to the decor so that the appearance of eurythmy³ may be convincing to the observer. How this result is to be attained, it is now my duty to show, and I will first speak on the right arrangement of the courtyards of houses.

¹ *imagines* = *simulacra* = *eidola* of Democritus, which are supposed to be transmitted from the object to the eye.

² The unit is a practical expedient for furnishing the various 'scantlings' or dimensions.

³ Eurythmy is the suitable display of details in their context. Book I. ii. 3.

III

- 1 CAVA aedium quinque generibus sunt distincta, quorum ita figurae nominantur: tuscanicum, corinthium, tetrastylon, displuviatum, testudinatium. Tuscanica sunt, in quibus trabes in atrii latitudine traiectae habeant interpensiva et collicias ab angulis parietum ad angulos tignorum incurrentes, item asseribus stillicidiorum in medium conpluvium deiectus. In corinthiis¹ isdem rationibus trabes² et conpluvia conlocantur, sed a parietibus trabes recedentes in circuitione circa columnas componuntur. Tetrastyla sunt, quae subiectis sub trabibus angularibus columnis et utilitatem trabibus et firmitatem praestant, quod neque ipsae magnum impetum coguntur habere neque ab interpensivis onerantur.
- 2 Displuviata autem sunt, in quibus deliquiae aream³ sustinentes stillicidia reiciunt. Haec hibernaculis maxime praestant utilitates, quod compluvia eorum⁴ erecta non obstant luminibus tricliniorum. Sed ea habent in refectionibus molestiam magnam, quod circa parietes stillicidia defluentia, continent fistulae, quae non celeriter recipiunt ex canalibus aquam defluentem itaque redundantes restagnant, et intestinum et parietes in eis generibus aedificiorum corrumpunt. Testudinata vero ibi fiunt, ubi

¹ corinthiis *G*: corinthii *H*.² traues *H*.³ aream *Gr*: arcam *H*.⁴ eorum *ed*: earum *H*.¹ *interpensiva*, cross-beams at right angles to main beams; frequent at Pompeii.² The internal angles where sloping roofs meet.³ Corinthian has more columns than tetrastyle.

CHAPTER III

ON THE PLAN OF A HOUSE

1. THE courtyards of houses are of five different styles, and the names of them are as follows: Tuscan, Corinthian, Tetrastyle, Displuviate, Vaulted. The Tuscan are those in which the beams which are carried across the atrium have trimmers¹ to them and valleys² running down from the angles of the walls to the angles of the beams; thus there is a delivery of the rainfall from the eaves into the middle of the court. In the Corinthian³ manner, the beams and open space⁴ are arranged in the same way, but the beams, starting from the walls, are fixed upon columns surrounding the open space. The tetrastyle courtyards have angle columns under the beams, which gain thereby in usefulness and strength, because they are not compelled to bear great pressure and are not loaded by the trimmers.

2. Displuviate courtyards are those in which the rafters which support the frame of the opening carry the gutters down.⁵ They are very advantageous for winter apartments because the central openings are raised and do not impede the lights of the triclinia. But there is this disadvantage in the upkeep: when the rain-water flows down, the pipes round the walls receive it, but do not quickly take the water flowing from the channels; as they receive it, they are clogged with the surplus water. Consequently the joiner's work and the walls are damaged. Vaulted courtyards are employed when

⁴ *interdius*, Varro, *R. R.* I. 13. 3.

⁵ See Plate J.

non sunt impetus magni et in contignationibus supra spatiosae redduntur habitationes.

- 3 Atriorum vero latitudines ac longitudines tribus generibus formantur. Et primum genus distribuitur, uti, longitudo cum in quinque partes divisa fuerit, tres partes latitudini dentur; alterum, cum in tres partes dividatur, duae partes latitudini tribuantur; tertium, uti latitudo in quadrato paribus lateribus describatur inque eo quadrato diagonius¹ linea ducatur, et quantum spatium habuerit ea linea
4 diagonii, tanta longitudo atrio detur. Altitudo eorum, quanta longitudo fuerit quarta dempta, sub trabes extollatur; reliquum lacunariorum et arcae supra trabes ratio habeatur.

Alis² dextra ac sinistra latitudinis, cum sit atrii longitudo ab³ xxx pedibus ad pedes xl, ex tertia parte eius constituatur. Ab xl ad pedes l longitudo dividatur in partes tres s,⁴ ex his una pars alis detur. Cum autem erit longitudo ab quinquaginta pedibus ad sexaginta, quarta pars longitudinis alis tribuatur. A pedibus lx ad lxxx longitudo dividatur in partes quattuor et dimidiam,⁵ ex his una pars fiat alarum latitudo. A pedibus octoginta ad pedes centum in quinque partes divisa longitudo iustam constituerit latitudinem alarum. Trabes earum liminares ita altae ponantur, ut altitudine latitudinibus sint aequales.

- 5 Tablinum, si latitudo atrii⁶ erit pedum viginti, dempta tertia eius spatio reliquum tribuatur. Si erit ab pedibus xxx ad xl, ex atrii latitudine tablino

¹ diagonios *Schn*: diagonius *H*.

² alis *G*: aliis *H*. ³ ad xxx *H*.

⁴ s *add. Ro*. ⁵ dimidiam *G*: dimidia *H*.

⁶ atrii *S*: atrium *H*.

the span is not great, and they furnish roomy apartments in the story above.

3. The length and breadth of the *atrium*¹ is planned in three ways. The first arrangement is to divide the length into five parts, and to give three of these to the width; the second divides the length into three parts and assigns two to the width; in the third arrangement a square is described upon the width, and the diagonal of the square is drawn: whatever is the size of the diagonal supplies the length of the atrium. 4. The height of the atrium to the underside of the beams is to be three-quarters of the length. The remaining quarter is to be assigned as the dimension of the ceiling and of the roof, above the beams.

The width of the *alae* or wings, on the right and the left, is to be one-third of the length of the atrium when it is from 30 to 40 feet; from 40 to 50 feet the length is to be divided into three parts and a half, and one is to be given to the *alae*. When the length is from 50 to 60 feet, a fourth part is to be assigned to the *alae*. From 60 to 80 feet let the length be divided into four parts and a half: of these one is to be the width of the *alae*. From 80 to 100 feet the length divided into five parts will determine the breadth of the *alae*. The lintel beams are to be placed so high, that, in height, the *alae* are equal to their breadth.

5. The *tablinum* or alcove, if the breadth of the atrium is 20 feet, must be two-thirds in width. If the breadth of the atrium is 30 to 40 feet, half is to

¹ This and similar terms will be understood by reference to Pl. I.

dimidium tribuatur. Cum autem ab XL ad LX, latitudo dividatur in partes quinque, ex his duo tablino constituentur. Non enim atria minora ab maioribus¹ easdem possunt habere symmetriarum rationes. Si enim maioribus symmetriis utemur in minoribus, neque tablino neque alae utilitatem poterunt habere, sin autem minorum in maioribus utemur, vasta et inmania in his ea erunt membra. Itaque generatim magnitudinum rationes exquisitas
6 et utilitati et aspectui conscribendas putavi. Altitudo tablini ad trabem adiecta² latitudinis octava constituitur. Lacunaria eius tertia latitudinis ad altitudinem adiecta extollantur.

Fauces minoribus atriis e tablini³ latitudine dempta tertia, maioribus dimidia constituentur.⁴ Imagines item alte cum suis ornamentis ad latitudinem sint constitutae.

Latitudines ostiorum⁵ ad altitudinem; si dorica erunt, uti dorica, si ionica erunt, uti ionica perficiantur, quemadmodum de thyromatis in quibus quarto libro rationes symmetriarum sunt expositae.

Conpluvii lumen latum latitudinis atrii ne minus quarta, ne plus tertia parte relinquatur; longitudo, uti atrii pro rata parte fiat.

7 Peristyla autem in transverso tertia parte longiora sint quam introssus.⁶ Columnae tam altae quam porticus latae fuerint peristylorum; intercolumnia

¹ ad maioribus *H.*

² adiecta *rec* : abiecta *H.*

³ & ablinii *H.*, et tablini *G.*

⁴ constituentur *G* : -atur *H.*

⁵ ostiorum *Joc* : eorum *H.*

⁶ introssus *H* : *inscrr.*

be given to the alcove. When the breadth is from 40 to 60, two-fifths are to be assigned to the alcove. For the smaller atria cannot have the same kind of symmetry as the larger. For if we use the symmetry of the larger atria in the smaller, it cannot be useful for the alcove or the wing. But if we use the symmetry of the smaller in the larger, the details will be huge and monstrous. Therefore I thought that according to their kinds the exact dimensions should be registered with a view both to use and to effect.

6. The height of the alcove to the cornice is to be one-eighth more than its breadth. The panelled ceiling is to be raised higher than the cornices by one-third of the breadth.

The main entrance for smaller atria is to be two-thirds of the width of the alcove; for larger atria, one-half. The portraits with their ornaments are to be fixed above at a height equal to the breadth of the alae.

The relation of the breadth to the height of the doors is to be in the Doric manner for Doric buildings, in the Ionic, for Ionic buildings, as in the case of Greek doorways of which the symmetrical relations have been set out in the fourth book.¹

The width of the opening of the compluvium is to be not less than a fourth, nor more than a third, of the width of the atrium; the length, in proportion to the atrium.

7. The peristyles² lie crosswise, and should be one-third wider than they are deep. The height of the columns is to be the same as the breadth of the colonnade of the peristyle. The inter-columniations

¹ The mediaeval cloister was developed from the peristyle in this sense. Cf. *amplissimum peristylum*. Cic. *Dom.* 116.

ne minus trium, ne plus quattuor columnarum crassitudine inter se distent. Sin autem dorico more in peristylo columnae erunt faciundae, uti in quarto libro de dorice scripsi, ita moduli sumantur, et ad eos modulos triglyphorumque rationes disponantur.

- 8 Tricliniorum quanta latitudo fuerit, bis tanta longitudo fieri debet. Altitudines omnium conclavorum, quae oblonga fuerint, sic habere debent rationem, uti longitudinis et latitudinis mensura componatur et ex ea summa dimidium sumatur, et quantum fuerit, tantum altitudini detur. Sin autem exhedrae aut oeci quadrati fuerint, latitudinis dimidia addita altitudines educantur. Pinacothecae uti exhedrae amplis magnitudinibus sunt constituendae. Oeci corinthii tetrastylisque quique aegyptii vocantur latitudinis et longitudinis,¹ uti supra tricliniorum symmetriae scriptae sunt, ita habeant rationem, sed propter columnarum interpositiones spatiosiores constituentur.

- 9 Inter corinthios autem et aegyptios hoc erit discrimen. Corinthii simplices habent columnas aut in podio positas aut in imo; supraque habeant epistylia et coronas aut ex intestino opere aut albario, praeterea supra coronas curva lacunaria ad circinum delumbata. In aegyptiis autem supra columnas epistylia et ab epistyliis ad parietes, qui sunt circa, inponenda est contignatio, supra coaxationem pavimentum, subdiu ut sit circumitus. Deinde supra epistylium ad perpendicularum inferiorum columnarum inponendae sunt minores quarta parte columna.

¹ latitudinis et longitudinis *Joc* : -nes *bis H*.

¹ Book IV. iii. 3.

are to extend not less than three or more than four diameters of the columns. But if the columns in the peristyle are to be in the Doric style, the modules are to be taken as I described in the fourth book¹ about Doric detail, and the columns and triglyphs arranged accordingly.

8. The length of *triclinia*, or dining-rooms, must be twice their width. The height of all apartments which are oblong must be so arranged that the length and breadth are added together; of this sum half is taken, and this gives the height. But if they shall be *exedrae* or square *oeci*,² the height is to be one and a half times the width. Picture galleries (like *exedrae*) are to be made of ample dimensions. Corinthian and tetrastyle halls and those which are called Egyptian, are to have the same proportion of length and breadth as in the description of the *triclinia*, but owing to the use of columns they are to be more spacious.

9. There is this difference between a Corinthian and an Egyptian *oecus*. The Corinthian has one row of columns placed either upon a stylobate or upon the ground. Above, it is to have architraves and cornices either of fine joinery or plaster, and above the cornices, curved ceilings rounded to a circular section. In the Egyptian saloons, however, architraves are placed above the columns, and floor joists are to be carried from the architraves to the walls opposite. On the floor boards a pavement is to be laid that there may be a balcony in the open. Then above the architrave, and perpendicularly above the lower columns, columns one-fourth shorter

² Large apartments, halls. There was an *exedra* and an *oecus* in the Museum at Alexandria. Strabo XVII. 794.

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Supra earum epistylia et ornamenta lacunariis ornantur, et inter columnas superiores fenestrae conlocantur; ita basilicarum ea similitudo, non corinthiorum tricliniorum videtur esse.

- 10 Fiunt autem etiam non italicae consuetudinis oeci, quos Graeci cyzicenos appellant. Hi conlocantur spectantes ad septentrionem et maxime viridia prospicientes, valvasque¹ habent in medio. Ipsi autem sunt ita longi et lati, uti duo triclinia cum circumitionibus inter se spectantia possint esse conlocata, habentque dextra ac sinistra lumina fenestrarum valvata,² uti de tectis per spatia fenestrarum viridia prospiciantur. Altitudinis eorum dimidia latitudinis addita constituuntur.
- 11 In his aedificiorum generibus omnes sunt faciendae earum symmetriarum rationes, quae sine inpeditione loci³ fieri poterunt, luminaque, parietum altitudinibus si non obscurabuntur, faciliter erunt explicata; sin autem inpedientur ab angustiis aut aliis necessitatibus, tunc erit⁴ ut ingenio et acumine de symmetriis detractioes aut adiectiones fiant, uti non dissimiles veris symmetriis perficiantur venustates.

¹ valvas *H G.*

² fen. viridia valvata *H* : viridia *del. Joc.*

³ loci *ed* : locis *H.*

⁴ tunc erit *G* : tenerit *H S.*

are to be placed. Above their architraves and ornaments they have panelled ceilings, and windows are placed between the upper columns. Thus the Egyptian halls resemble basilicas¹ rather than Corinthian apartments.

10. Other halls in a foreign manner are those which the Greeks call Cyzicene. These are situated with a north aspect, and especially with an outlook upon gardens; they have folding windows in the middle. The halls themselves are broad and long enough to have two triclinia facing each other, with room to pass round; and these, on both hands, have garden windows with folding lights, so that the guests, under cover,² may have a view of the garden.³ The height of the hall must be one and a half times its width.

11. In buildings of this kind, all the rules of symmetry must be followed, which are allowed by the site, and the windows will be easily arranged unless they are darkened by high walls opposite. But if they are obstructed by the narrowness of the street or by other inconveniences, skill and resource must alter the proportions by decreasing or adding, so that an elegance may be attained in harmony with the proper proportions.

¹ Santa Maria Maggiore at Rome was perhaps a third-century basilica in a private house. At any rate, the later (Liberian) building is of this type.

² *tectum quo imbris causa vitandi succederet.* Cic. Dom. 116.

³ *Cyrus aiebat viridiorum διαφάσεις latissimis luminibus non tam esse suaves.* Cic. Att. II. 3.

IV

1 NUNC explicabimus, quibus proprietatibus genera aedificiorum ad usum et caeli regiones apte¹ debeant expectare. Hiberna triclina et balnearia uti occidentem hibernum spectent, ideo quod vespertino lumine opus est uti, praeterea quod etiam sol occidens adversus habens splendorem, calorem remittens efficit vespertino tempore regionem tepidiorem. Cubicula et bybliothecae ad orientem spectare debent; usus enim matutinum postulat lumen, item in bybliothebis libri non putrescent. Nam quaecumque ad meridiem et occidentem spectant, ab tiniis² et umore libri vitiantur, quod venti umidi advenientes procreant eas et alunt infundentesque umidos spiritus pallore volumina conrumpunt.

2 Triclina verna et autumnalia ad orientem; tum³ enim praetenta luminibus adversus solis impetus progrediens ad occidentem efficit ea temperata ad id tempus, quo opus solitum est uti. Aestiva ad septentrionem, quod ea regio, non ut reliquae per solstitium propter calorem efficiuntur aestuosae, ea quod est aversa a solis cursu, semper refrigerata et salubritatem et voluptatem in usu praestat. Non minus pinacothecae et plumariorum textrina⁴ pictorumque officinae, uti colores eorum in opere propter constantiam luminis inmutata permaneant qualitate.

¹ apte *Fav*: actae *H*.

² tiniis *H*: Verg. *G.* IV. 246.

³ tum *Schn*: cum *H*.

⁴ textrina *S*: extrina *H*.

¹ Varro, *R. R.* I. 13. 7. Varro by changing doors and windows at Corcyra brought his men safely through a pestilence, *ib.* I. 4. 5.

² *cubicula—diurna nocturna.* Plin. *Ep.* I. 3. 1.

CHAPTER IV

ON THE ASPECT OF THE SEVERAL APARTMENTS

1. Now we will explain the adjustments by which the various apartments may look out suitably to their proper aspects.¹ The baths and winter dining-rooms should look towards the winter setting sun, because there is need of the evening light. Besides, when the setting sun faces us with its splendour, it reflects the heat and renders this aspect warmer in the evening. Private rooms² and libraries should look to the east, for their purpose demands the morning light. Further, the books in libraries will not decay. For in apartments which look to the south and west, books are damaged by the bookworm and by damp, which are caused by the moist winds on their approach, and they make the papyrus rolls mouldy by diffusing moist air.

2. The spring and autumn dining-rooms should look to the east. For exposed as they are to the light, the full power of the sun moving to the west renders them temperate at the time when the need to use them is customary. The summer dining-rooms should have a northern aspect. For while the other aspects, at the solstice, are rendered oppressive by the heat, the northern aspect, because it is turned away from the sun's course, is always cool, and is healthy³ and pleasant in use. Not less should the picture galleries, the weaving-rooms of the embroiderers, the studios of painters, have a north aspect, so that, in the steady light, the colours in their work may remain of unimpaired quality.

³ Varro, *R. R. I.* 4. 5.

- 1 Cum ad regiones caeli ita ea fuerint disposita, tunc etiam animadvertendum est, quibus rationibus privatis aedificiis propria loca patribus familiarum et quemadmodum communia cum extraneis aedificari debeant. Namque ex his quae propria sunt, in ea non est potestas omnibus intro eundi nisi invitatis, quemadmodum sunt cubicula, triclinia, balneae ceteraque, quae easdem habent usus rationes. Communia autem sunt, quibus etiam invocati suo iure de populo possunt venire, id est vestibula, cava aedium, peristylia, quaeque eundem habere possunt usum. Igitur is, qui communi sunt fortuna, non necessaria magnifica vestibula nec tabulina neque atria, quod in aliis officia praestant ambiundo neque¹
- 2 ab aliis ambiuntur. Qui autem fructibus rusticis serviunt, in eorum vestibulis stabula, tabernae, in aedibus cryptae, horrea, apothecae ceteraque, quae ad fructus servandos magis quam ad elegantiae decorem possunt esse, ita sunt facienda. Item feneratoribus et publicanis commodiora et speciosiora et ab insidiis tuta, forensibus autem et disertis elegantiora et spatiosiora ad conventos excipiundos, nobilibus vero, qui honores magistratusque gerundo praestare debent officia civibus, faciunda sunt vestibula regalia alta, atria et peristylia amplissima,² silvae ambulationesque laxiores ad decorem maies-

¹ neque *Perr* : quae *H*.

² *Cf.* porticum pavimentatam . . . amplissimum peristylum. *Cic. Dom.* 116.

¹ Crowded vestibule of jurisconsult. *Cic. de Or.* I. 200.

² Wine-store often in roof to receive the smoke. *Hor. Od.* III. 8. 11.

CHAPTER V

ON BUILDING SUITABLY FOR DIFFERENT RANKS OF
SOCIETY

1. WHEN we have arranged our plan with a view to aspect, we must go on to consider how, in private buildings, the rooms belonging to the family, and how those which are shared with visitors, should be planned. For into the private rooms no one can come uninvited, such as the bedrooms, dining-rooms, baths and other apartments which have similar purposes. The common rooms are those into which, though uninvited, persons of the people can come by right, such as vestibules,¹ courtyards, peristyles and other apartments of similar uses. Therefore magnificent vestibules and alcoves and halls are not necessary to persons of a common fortune, because they pay their respects by visiting among others, and are not visited by others. 2. But those who depend upon country produce must have stalls for cattle and shops in the forecourt, and, within the main building, cellars, barns, stores² and other apartments which are for the storage of produce rather than for an elegant effect. Again, the houses of bankers and farmers of the revenue should be more spacious and imposing and safe from burglars. Advocates and professors of rhetoric should be housed with distinction, and in sufficient space to accommodate their audiences. For persons of high rank who hold office and magistracies, and whose duty it is to serve the state, we must provide princely vestibules, lofty halls and very spacious peristyles, plantations and broad avenues finished in a majestic

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tatis perfectae; praeterea bybliotheças, basilicas non dissimili modo quam publicorum operum magnificentia comparatas, quod in domibus eorum saepius et publica consilia et privata iudicia arbitriaque conficiuntur.

- 3 Ergo si his rationibus ad singulorum generum personas, uti in libro primo de decore est scriptum, ita disposita erunt aedificia, non erit quod reprehendatur; habebunt enim ad omnes res commodas et emendatas explicationes. Earum autem rerum non solum erunt in urbe aedificiorum rationes, sed etiam ruri, praeterquam quod in urbe atria proxima ianuis solent esse, ruri ab pseudourbanis statim peristylia, deinde tunc atria habentia circum porticus pavimentatas¹ spectantes ad palaestras et ambulationes.

Quoad potui urbanas rationes aedificiorum summatim perscribere, proposui; nunc rusticorum expeditionum, ut sint ad usum commodae quibusque rationibus conlocare oporteat eas, dicam.

VI

- 1 PRIMUM de salubritatibus, uti in primo volumine de moenibus conlocandis scribuntur, regiones aspiciantur et ita villae conlocentur. Magnitudines earum ad modum agri copiasque fructuum con-

¹ pavimentatas *Joc*: pavimenta *H*.

¹ Book I. ii. 5.

manner; further, libraries and basilicas arranged in a similar fashion with the magnificence of public structures, because, in such palaces, public deliberations and private trials and judgments are often transacted.

3. Therefore if buildings are planned with a view to the status of the client, as was set forth in the first book under the head of decor,¹ we shall escape censure. For our rules will be convenient and exact in every respect. Moreover, we shall take account of these matters, not only when we build in town, but in the country; except that, in town, the halls adjoin the entrance, in the country the peristyles of mansions built town-fashion come first, then the atria surrounded by paved colonnades overlooking the palaestra and the promenades.

I have set forth as I am able the general methods of building in town. I will now state the methods of building in the country,² with a view to convenience in use, and especially to the disposition of the site.

CHAPTER VI

ON FARM BUILDINGS

1. AND first with respect to salubrity: the aspects of sites must be examined, and the farm-houses placed, as we have written in the first volume about the positions of town walls.³ The size of a farm-house is to be arranged to suit the amount of land

¹ *illorum (sc. anticorum) villae rusticae erant maioris pretii quam urbanae quae nunc sunt pleraque contra.* Varro, *R. R.* I. 13. 6.

² Book I. iv. Varro, *R. R.* I. 4. 4.

- parentur. Chortes magnitudinesque earum ad pecorum numerum, atque quot¹ iuga bouum opus fuerint ibi versari, ita finiantur. In chorte culina quam calidissimo loco designetur.² Coniuncta autem habeat bubilia, quorum praesepia ad focum et orientis caeli regionem spectent, ideo quod boves lumen et ignem spectando horridi non fiunt; item agricolae regionum inperiti non putant oportere aliam regionem caeli boves spectare nisi ortum solis. Bubilium autem debent esse latitudines nec minores pedum denum nec maiores v denum; longitudo, uti singula iuga ne minus pedes occupent septenos. Balnearia item coniuncta sint culinae; ita enim lavationi rusticae ministratio non erit longe. Torcular item proximum sit culinae; ita enim ad olearios fructus commoda erit ministratio. Habeatque coniunctam vinariam cellam habentem ab septentrione lumina fenestrarum; cum enim alia parte habuerit, quae sol calfacere possit, vinum, quod erit in ea cella, confusum ab calore efficietur inbecillum.
- 3 Olearia autem ita est conlocanda, ut habeat a meridie calidisque regionibus lumen; non enim debet oleum congelari, sed tempore caloris extenuari. Magnitudines autem earum ad fructuum rationem et numerum doliorum sunt faciundae, quae, cum sint cullearia, per medium occupare debent pedes quaternos. Ipsum autem torcular, si non coeleis torquetur sed vectibus et prelo premetur, ne minus longum pedes xl constituatur; ita enim erit vectiario

¹ quod *H.*² desinetur *H.*¹ Varro, *R. R.* I. 13. 1.² Book I. iv. 2.³ Varro, *R. R.* I. 13. 7.

and of the crops. The farm-yards and their dimensions are to correspond to the number of cattle and the yoke of oxen which are required. In the farm-yard the warmest place must be assigned to the kitchen, and, adjoining this, to the cowhouses,¹ the mangers of which are to look towards the hearth and towards the east, for cattle which face light and heat do not lose their sleekness. And even farmers who are ignorant about aspects, do not think that cattle ought to face any quarter of the sky but the east. 2. The width of the stalls should be not less than ten nor more than fifteen feet; lengthwise each yoke should have not less than seven feet. The baths also should be next to the kitchen; in this way the service of baths for the farm will be near by. The oilpress should be next the kitchen, for in this way the service will be convenient for the olive harvest. Next let there be the wine-cellar, having windows with light from the north.² For when light is drawn from a quarter heated by the sun, the wine will be affected by the heat, and thin.

3. The oil store is to be so situated as to receive light from the south and the warm quarter.³ For the oil should not be congealed, but kept thin by the warm weather. The dimensions of the store should answer to the amount of the harvest and the number of the jars. When these contain 20 amphorae, they should occupy four feet each on the average. The press, if it is not turned by a screw,⁴ but is worked by levers and a press-beam, is to be not less than 40 feet long. This will leave room for

⁴ This was a Greek invention. Plin. *N. H.* XVIII. 317.

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spatium expeditum. Latitudo eius ne minus pedum senum denum; nam sic erit ad plenum opus facientibus libera versatio et expedita. Sin autem duobus prelis loco opus fuerit, quattuor et viginti pedes latitudini dentur.

- 4 Ovilia et caprilia ita sunt magna facienda, uti singula pecora areae ne minus pedes quaternos et semipedem, ne plus senos possint habere. Granaria sublinita¹ et ad septentrionem aut aquilonem spectantia disponantur; ita enim frumenta non poterint cito concalescere, sed ab flatu refrigerata diu servantur. Namque ceterae regiones procreant curculionem et reliquas bestiolas, quae frumentis solent nocere. Equilibus, quae maxime in villa loca calidissima fuerint, constituentur, dum ne ad focum spectent; cum enim iumenta proxime ignem stabulantur, horrida fiunt.
- 5 Item non sunt inutilia praesepia, quae conlocantur extra culinam in aperto contra orientem; cum enim in hieme anni sereno caelo in ea traducuntur matutino boves, ad solem pabulum capientes fiunt nitidiores. Horrea, fenilia, farraria, pistrina extra villam facienda videntur, ut ab ignis periculo sint villae tutiores. Si quid delicatius in villis faciundum fuerit, ex symmetriis quae in urbanis supra scripta sunt constituta, ita struantur, uti sine inpeditione rusticae utilitatis aedificentur.
- 6 Omniaque aedificia ut luminosa sint, oportet curari; sed quae sunt ad villas, faciliora videntur esse, ideo quod paries nullius vicini potest opstare,

¹ sublinita *Gr*: sublinata *H*: cf. liniantur, *supra* V. x. 3.

¹ Book I. iv. 2.

the man who works the levers. The width of the room must be not less than 16 feet, so that when the men are fully at work, their movements will be free and easy. But if two presses are required in the place, the width should be 24 feet.

4. The sheep and goat folds are to be such a size that each animal occupies not less than $4\frac{1}{2}$ or more than 6 feet. The granaries are to have a concrete floor, and a north or north-east aspect.¹ For in this way the corn will not soon become overheated, but keeps good, being cooled by the draughts. For other aspects produce the weevil and other small creatures, which usually damage the corn. Stables are to be so placed as to have the warmest part of the farm buildings, provided they do not look towards the hearth. For when draught horses are stabled next the fire, they lose their sleekness.

5. Further, mangers are not without their advantages, which are put outside the kitchen in the open on the east. For when the cattle are led up in fine winter weather for their morning feed, they become more sleek by eating their fodder in the sun. Barns, stores for hay and meal, bakehouses, should be outside the farm-house, that they may be more safe from fire. If a touch of elegance² is required in a farm-house, it should be built in a symmetrical manner, which things are described above for town houses, yet without interfering with the needs of agriculture.

6. Care is required that all buildings should be well lighted. This is more easy in farm buildings because there are no party walls to interfere;

¹ *elegantior aedificet agricola, nec sit tamen aedificator.* Colum. I. 4. 1. Cf. *minus aedificator.* Nepos, Atticus. 13.

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in urbe autem aut communium parietum altitudines aut angustiae loci inpediundo faciunt obscuritates. Itaque de ea re sic erit experiundum. Ex qua parte lumen oporteat sumere, linea tendatur ab altitudine parietis, qui videtur obstare, ad eum locum, quo oporteat inmittere, et si ab ea linea in altitudinem cum prospiciatur, poterit spatium puri caeli amplum videre, in eo loco lumen erit sine inpeditione.

- 7 Sin autem officient trabes seu limina¹ aut con-
tignationes, de superioribus partibus aperiatur et
ita inmittatur. Et ad summam ita est gubernandum,
ut, ex quibuscumque partibus caelum prospici poterit,
per ea fenestrarum loca relinquantur; sic enim
lucida erunt aedificia. Cum autem in tricliniis
ceterisque conclavibus maximus est usus luminum,
tum etiam itineribus, clivis, scalis, quod in his saepius
alius aliis obviam venientes ferentes sarcinas solent
incurrere.

Quoad potui, distributiones operum nostratium
ut sint aedificatoribus non obscurae, explicui; nunc
etiam, quemadmodum Graecorum consuetudinibus
aedificia distribuuntur, uti non sint ignota, summam
exponam.

VII

- 1 ATRIIS Graeci quia non utuntur, neque aedificant,
sed ab ianua introeuntibus itinera faciunt latitudi-
nibus non spatiosis, et ex una parte equilia,² ex

¹ limina *ed*: lumina *H*.

² equilia *Joc*: aequalia *H*.

whereas in cities, the heights of party walls or the narrow streets are in the way, and cause lack of light. Therefore trial should be made as follows. In the quarter from which light is required, a line should be drawn from the top of the party wall which seems to obstruct, to the point where light should be admitted. If the amount of open sky seems sufficient when we look up from that line, the light will not be obstructed.

7. But if the light is hindered by beams or lintels or flooring, there must be an opening made above to admit the light. And the whole must be so controlled that from whatever quarter the sky can be seen, window openings must be left there;¹ for in this way the buildings will be well lighted. Now there is special need of light in dining-rooms and other apartments, and also in passages, sloping ways, and staircases, because, in these, persons who come with burdens often run into one another when they meet.

As far as I can, I have explained the arrangement of our buildings that they may not be obscure to our own builders; now I will also explain briefly how buildings are arranged according to Greek custom, so that they too may not be unknown.

CHAPTER VII

ON GREEK MANSIONS

1. THE Greeks,² not using atria, do not build as we do; but as you enter, they make passages of scanty width with stables on one side, and the

¹ *per ea*, neuter of general reference.

² The reference is probably to the Alexandrian age.

altera ostiariis cellas, statimque ianuæ interiores finiuntur. Hic autem locus inter duas ianuas graece *thyroron* appellatur. Deinde est introitus in peristylon. Id peristylum in tribus partibus habet porticus inque¹ parte, quæ spectat ad meridiem, duas antas inter se spatio amplo distantes, in quibus trabes inveniuntur, et quantum inter antas distat, ex eo tertia adempta spatium datur introrsus. Hic locus apud nonnullos prostras, apud alios pastas nominatur.

2 In his locis introrsus constituuntur oeci magni, in quibus matres familiarum cum lanificis habent sessionem. In prostadis² autem dextra ac sinistra cubicula sunt conlocata, quorum unum thalamus, alterum amphithalamus dicitur. Circum autem in porticibus triclinia cotidiana, cubicula, etiam cellae³ familiaricæ constituuntur. Haec pars aedificii gynaeconitis appellatur.

3 Coniunguntur autem his domus ampliores habentes lautiora peristylia, in quibus pares sunt quattuor porticus altitudinibus, aut una, quæ ad meridiem spectat, excelsioribus columnis constituitur. Id autem peristylum, quod unam altiore habet porticum, rhodiacum dicitur. Habent autem eae domus vestibula egregia et ianuas proprias cum dignitate porticusque peristyliorum albariis et tectoriis et ex intestino opere lacunariis ornatas, et in porticibus, quæ ad septentrionem spectant, triclinia cyzicena et pinacothecas, ad orientem autem bybliothecas, exhedras ad occidentem, ad meridiem vero spectantes oecos quadrata ostia ampla magnitudine, uti faciliter in eo quattuor tricliniis stratis ministrationum ludorumque operis locus possit esse spatiosus.

¹ inque *rec* : in quæ *H*. ² prostadis *Joc* : prostadii *H*.

³ sellæ *Gr* (Varro *R. R. I.* 13. 4).

porter's rooms on the other; and these immediately adjoin the inner entrance. The space between the two entrances is called in Greek *thyronon*. You then enter the peristyle. This has colonnades on three sides. On the side which looks southward, there are two piers at a fair distance apart, on which beams are laid. The space behind is recessed two-thirds of the distance between the piers. The recess by some is called *prosta*, *pastas* by others.¹

2. As we pass in, there is the Great Hall in which the ladies sit with the spinning women. Right and left of the recess are the bedchambers, of which one is called the *thalamus*, the other the *amphithalamus*. Round the colonnades are the ordinary dining-rooms, the bedrooms and servants' rooms. This part of the building is called the women's quarter, *gynaecoonitis*.

3. Next to this is a larger block of buildings with more splendid peristyles; in these the colonnades are equal in height, or else the colonnade which looks to the south has loftier columns. The peristyle which has one colonnade higher is called Rhodian. These buildings have splendid approaches and doorways of suitable dignity. The colonnades of the peristyles are finished with ceilings of stucco, plaster, and fine wood panelling. In the colonnades which face the north are Cyzicene triclinia and picture galleries; on the east the libraries, the exedrae on the west; halls and square entrances² face the south that there may be ample room for four triclinia, and for the servants who attend them and assist in the amusements.

¹ Ap. Rh. I. 789.

² The *quadrata ostia* should perhaps be retained as halls open in front to the air.

- 4 In his oecis fiunt virilia convivia; non enim fuerat institutum matris familiarum eorum moribus accumbere. Haec autem peristylia domus andronitides dicuntur, quod in his viri sine interpellationibus mulierum versantur. Praeterea dextra ac sinistra domunculae constituuntur habentes proprias ianuas, triclinia et cubicula commoda, uti hospites advenientes non in peristylia sed in ea hospitalia recipiantur. Nam cum fuerunt Graeci delicatiores et fortuna opulentiores, hospitibus advenientibus instruebant triclinia, cubicula, cum penu cellas, primoque die ad cenam invitabant, postero mittebant pullos, ova, holera, poma reliquasque res agrestes. Ideo pictores ea, quae mittebantur hospitibus, picturis imitantes xenia appellaverunt. Ita patres familiarum in hospitio non videbantur esse peregre, habentes secretam
- 5 in his hospitalibus liberalitatem.¹ Inter duo autem peristylia et hospitalia itinera sunt, quae mesauloe dicuntur, quod inter duas aulas media sunt interposita; nostri autem eas andronas appellant.

Sed hoc valde est mirandum, nec enim graece nec latine potest id convenire. Graeci enim *andronas* appellant oecus, ubi convivia virilia solent esse, quod eo mulieres non accedunt. Item aliae res sunt similes, uti *xystus*, *prothyrum*, *telamones*² et nonnulla alia eius modi. *Xystos* enim est graeca appellatione porticus ampla latitudine, in qua athletae per hiberna tempora exercentur; nostri autem *hypaethrus* ambulationes *xysta*³ appellant, quas

¹ post liberalitatem H paginam versam folii 87 vacuam exhibet.

² thalamones H.

³ xysta ed: xysti H.

¹ The paintings of still life by Dutch painters, correspond to the groups of fruit, poultry, etc. in Roman mosaics.

4. In these halls men's banquets are held. For it was not customary for women to join men at dinner. Now these peristyles are called the men's block, for in them men meet without interruption from the women. Moreover, on the right and left lodges are situated with their own entrances, dining-rooms and bedrooms, so that guests on their arrival may be received into the guest-houses and not in the peristyles. For when the Greeks were more luxurious and in circumstances more opulent, they provided for visitors on their arrival, dining-rooms, bedrooms, and store-rooms with supplies. On the first day they invited them to dinner; afterwards they sent poultry, eggs, vegetables, fruit, and other country produce. Therefore painters, when they portrayed what was sent to guests, called them guest-gifts.¹ Thus the heads of families in a guest-house² do not seem to be away from home when they enjoy private generosity in the visitors' quarters. 5. Now between the two peristyles and the visitors' quarters there are passages called *Mesauloe*, because they are between the two *aulae* or halls. But we call them *Andrones*, the men's quarters.

It is very remarkable that this suits neither Greek nor Latin usage. For the Greeks call *andrones* the halls where the men's banquets take place, because women are excluded. Yet other terms are of like application, such as *xystus*, *prothyrum*, *telamones*, and so forth. For *xystus* in its Greek signification is a colonnade of ample breadth where the athletes are trained in the winter;³ but we give the name of *xysta* to promenades in the open, which the Greeks

¹ *hospitium*, *Acts* xxviii. 23.

³ Repeated from Book V. xi. 4.

Graeci *paradromidas* dicunt. Item *prothyra* graece dicuntur, quae sunt ante in ianuas vestibula, nos autem appellamus *prothyra*, quae graece dicuntur *diathyra*.

- 6 Item si qua virili figura signa mutulos aut coronas sustinent, nostri telamones appellant, cuius rationes,¹ quid ita aut quare dicantur, ex historiis non inveniuntur, Graeci vero eos *atlantas* vocitant. Atlas enim formatur historia sustinens mundum, ideo quod is primum cursum solis et lunae siderumque omnium versationum rationes vigore animi sollertiaque curavit hominibus tradenda, eaque re² a pictoribus et statuariis deformatur pro eo beneficio sustinens mundum, filiaeque eius Atlantides, quas nos vergilias, Graeci autem *pliadas* nominant, cum
7 sideribus in mundo sunt dedicatae. Nec tamen ego, ut mutetur consuetudo nominationum aut sermonis,³ ideo haec proposui, sed uti non sint ignota philologis, exponenda iudicavi.

Quibus consuetudinibus aedificia italico more et Graecorum institutis conformantur, exposui et de symmetriis singulorum generum proportionem perscripsi. Ergo⁴ quoniam de venustate decoreque ante est conscriptum, nunc exponemus de firmitate, quemadmodum ea sine vitiis permanentia ad vetustatem conlocentur.

¹ ratione *H*.

³ sermones *H*.

² re *Joc* : res *H*.

⁴ ergo *G* : ero *H*.

call *paradromides*. The Greeks give the name *prothyra* to the vestibules which are in front and serve as the entrance; we call *prothyra* what, in Greek are named *diathyra*.¹

6. Again, if statues of the male figure support brackets or cornices, we call them *telamones*, nor do we find in any treatises what they are and why they are so called. But the Greeks call them *Atlantes*. For, in history,² Atlas is represented as sustaining the universe, because he was the first by his powerful intellect and skill to set forth to mankind the sun's course and the revolutions of the moon and all the stars. And therefore because of this service he is represented by painters and statuary as sustaining the world. His daughters, the *Atlantides*, whom we call *Vergiliae* and the Greeks *Pleiades*, are placed among the constellations in the universe. 7. I have put this forth not with the purpose of changing any nomenclature or language in common use, but I thought that these explanations should not be unknown to scholars.

I have expounded the traditions by which buildings are designed in the Italian manner, and by Greek rules, and have enumerated the proportions which determine the symmetries of the different styles. We have already, therefore, written on grace and propriety in architecture; it remains to deal with stability and the means by which buildings may be planned so as to endure without defect.³

¹ Wicket-gate at the front door.

² Euhemerus, in a work translated by Ennius, taught the doctrine represented here, that the gods were originally famous men.

³ Book I. iii. 2.

VIII

- 1 AEDIFICIA quae plano pede instituuntur, si fundamenta eorum facta fuerint ita, ut¹ in prioribus libris de muro et theatris nobis est expositum, ad vetustatem ea² erunt sine dubitatione firma. Sin autem hypogea concamarationesque instituentur, foundationes eorum fieri debent crassiores, quam quae in superioribus aedificiis structurae sunt futurae. Eorumque parietes, pilae, columnae ad perpendicularum inferiorum medio conlocentur, uti solido respondeant; nam si in pendentibus onera fuerint parietum aut columnarum, non poterint habere perpetuam firmitatem.
- 2 Praeterea inter lumina secundum pilas et antas postes si supponentur, erunt non vitiosae. Limina enim et trabes structuris cum sint oneratae, medio spatio pandantes frangunt sublisi³ structuras; cum autem subiecti fuerint et subcuneati postes, non patiuntur insidere⁴ trabes neque eas laedere.
- 3 Item administrandum est, uti levent onus parietum fornicationes cuneorum⁵ divisionibus et ad centrum respondentes earum conclusurae. Cum enim extra trabes aut liminum capita arcus cuneis erunt conclusae, primum non pandabit materies levata onere; deinde, si quod vetustate vitium ceperit, sine molitione fulturarum facilliter mutabitur.
- 4 Itemque, quae pilatim aguntur aedificia et cune-

¹ ut *G*: aut *H*.² eae *H*.³ sublisi *e*, *Sulp*: sub lysi *H*.⁴ insidera *H*.⁵ cuneorum *H*: cum eorum.¹ Book I. v. 1.² Book V. iii. 3.³ *pendo* = overhang. Lucr. vi. 195.⁴ *Voussoirs* = wedge-shaped stones of an arch.

CHAPTER VIII

ON THE STABILITY OF BUILDINGS

1. BUILDINGS which start from the level of the ground, if the foundations are so laid, as we have explained in previous books with reference to city walls¹ and theatres,² will assuredly be solid and durable. But if there are spaces underground and vaulted cellars, the foundations must be wider than the structures in the upper parts of the building. The party walls, the piers, the columns, are to be placed with their centres perpendicularly above the lower parts, so as to correspond to the solid. For if the weight of the dividing walls or of the columns is over open spaces,³ it cannot be permanently sustained.

2. Further, if supports are put for the piers and pilasters between the windows, these faults will be avoided. For when lintels and bressumers are loaded with walling, they sag in the middle and cause fractures by settlement; but when piers are placed underneath and wedged up, they do not allow the beams to settle and injure the structure above.

3. We must also contrive to relieve the weight of the walling by arches with their voussoirs,⁴ and their joints directed to a centre. For when arches, with their voussoirs, are carried outside the beams and lintels, in the first place the wood relieved of its burden will not sag; in the second place, if it decays in course of time, it will easily be replaced without the labour of shoring up.

4. Moreover, when buildings rest upon piers, and

orum divisionibus coagmentis ad centrum respondentibus fornices concluduntur, extremae pilae in his latiores spatio sunt faciundae, uti vires eae habentes resistere possint, cum cunei ab oneribus parietum pressi per coagmenta ad centrum se prementes extruderent incumbas. Itaque si angulares pilae erunt spatiosis magnitudinibus, continendo cuneos firmitatem operibus praestabunt.

5 Cum in his rebus animadversum fuerit, uti ea diligentia in his adhibeatur, non minus etiam observandum est, uti omnes structurae perpendiculari respondeant neque habeant in ulla parte proclinationes. Maxima autem esse debet cura substructionum, quod in his infinita vitia solet facere terrae congestio. Ea enim non potest esse semper uno pondere, quo solet esse per aestatem, sed hibernis temporibus recipiendo ex imbribus aquae multitudinem crescens et pondere et amplitudine dirumpit et extrudit structurarum saeptiones.

6 Itaque, ut huic vitio medeatur, sic erit faciundum, ut primum pro amplitudine congestionis crassitudo structurae constituatur. Deinde in frontibus anterides, sive erismae sunt, una struantur, eaeque inter se distent tanto spatio, quanta altitudo substructionis est futura, crassitudine¹ eadem, qua substructio; procurrat autem ab imo, pro quam² crassitudo constituta fuerit substructionis, deinde contrahatur gradatim, ita uti summam habeat prominentiam, quanta operis est crassitudo.

¹ crassitudine *Joc* : -nis *H*.

² pro quam *Ro* : per quam *H*.

¹ In these sections, Vitruvius furnished the mediaeval builders with the main principles of Gothic architecture. *Cf.*

arches are constructed with voussoirs and with joints directed to a centre, the end piers in the buildings are to be set out of greater width, so that they may be stronger and resist when the voussoirs, being pressed down by the weight of the walling owing to the jointing, thrust towards the centre and push out the imposts. Therefore if the angle piers are of wide dimensions, they will restrain the thrust and give stability to the buildings.¹

5. When proper attention has been given herein that such care be taken, we must not less be on our guard that every part of a building maintains its perpendicular and that no part leans over. But the greatest care must be taken in the substructures, because, in these, immense damage is caused by the earth piled against them. For it cannot remain of the same weight as it usually has in the summer: it swells in the winter by absorbing water from the rains. Consequently by its weight and expansion it bursts and thrusts out the retaining walls.

6. To avoid this damage, therefore, we must proceed as follows. The thickness of the walling must answer to the amount of earth. Next, supporting walls or buttresses are to be carried up at the same time. The interval between them is to be the same as the height of the substructure, and the thickness that of the substructure. They are to project at the base in accordance with the thickness determined for the substructure. Then they are to be gradually diminished, so that at the top they may project as much as the thickness of the walling.

Seneca, *Ep.* 95. 53. *Societas nostra lapidum fornicationi simillima est: quae casura nisi invicem obstarent, hoc ipso sustinetur.*

- 7 Praeterea introrsus contra terrenum coniuncta muro serratim struantur, uti singuli dentes ab muro tantum distent, quanta altitudo futura erit substructionis; crassitudines ¹ autem habeant dentium structurae uti muri. Item in extremis angulis cum recessum fuerit ab interiore angulo spatio altitudinis substructionis, in utramque partem signetur, et ab his signis diagonius ² structura conlocetur, et ab ea media altera coniuncta cum angulo muri. Ita dentes et diagonioe ³ structurae non patientur tota vi premere murum, sed dissipabunt retinendum ⁴ impetum congestionis.⁵
- 8 Quemadmodum sine vitiis opera constitui oporteat et uti caveatur incipientibus, exposui. Namque de tegulis aut tignis aut asseribus mutandis non est eadem cura quemadmodum de his, quod ea, quamvis sunt vitiosa, faciliter mutantur. Ita quae ⁶ nec solidi quidem putantur esse, quibus rationibus haec poterint esse firma et quemadmodum instituantur, exposui.
- 9 Quibus autem copiarum generibus oporteat uti, non est architecti potestas, ideo quod non in omnibus locis omnia genera copiarum nascuntur, ut in proximo volumine est expositum; praeterea in domini est potestate, utrum latericio an caementicio an saxo quadrato velit aedificare. Itaque omnium operum probationes tripertito considerantur, id est fabrili subtilitate et magnificentia et dispositione. Cum magnificenter opus perfectum aspicietur, a domini ⁷ potestate inpensae laudabuntur; cum subtiliter,

¹ crassitudinis *H.*² diagonios *Joc*: -nius *H S.*³ diagoniae *H.*⁴ retinendo *rec*: -dum *H.*⁵ congestiones *H S.*⁶ itaque *H.*⁷ a domini *Meister*: ab omni *H.*

7. Further, against the earth on the inside, the wall must have projections like the teeth of a saw, such that the intervals between them are equal to the height of the substructure. The thickness of the teeth must be that of the main wall. Further, in the outer angles of the substructure, taking a distance from the internal angle equal to the height of the substructure, we must mark a point on either side and a diagonal wall is to be built between them, and from the middle of the diagonal wall, another wall is to be built to the interior angle of the main wall. The teeth and the diagonal walls will not allow the full pressure to fall upon the main wall but will distribute the thrust of the earth, which we have to hold in check.

8. How buildings can be carried out so as to avoid failure, and how precautions must be taken in the first stages, has been explained. For the same care is not needful in repairing roof tiling, or principals or rafters, which if faulty are easily repaired, as in the foundations. I have also described how those parts of a building which are not considered to belong to the solid can be made stable, and how they are to be constructed.

9. An architect cannot control the kinds of material which it is necessary to use, for the reason that not all kinds of material occur in all places, as was explained in the last book.¹ Besides, the client decides whether he is to build in brick or rubble or ashlar. Therefore the test of all building is held to be threefold: fine workmanship, magnificence, architectural composition. When a building has a magnificent appearance, the expenditure of those who control it, is praised. When the craftsmanship is

¹ Book V. vi. 7; xii. 5.

officinatoris probabitur exactio; cum vero venuste proportionibus et symmetriis habuerit auctoritatem, 10 tunc fuerit gloria area¹ architecti. Haec autem recte constituuntur, cum is et a fabris et ab idiotis patiaturs accipere se consilia. Namque omnes homines, non solum architecti, quod est bonum, possunt probare, sed inter idiotas et eos hoc est discrimen, quod idiota, nisi factum viderit, non potest scire, quid sit futurum, architectus autem, simul animo constituerit, antequam inceperit, et venustate et usu et decore quale sit futurum, habet definitum.

Quas res privatis aedificiis utiles putavi et quemadmodum sint faciundae, quam apertissime potui, perscripsi; de expolitionibus² autem eorum, uti sint elegantes et sine vitiis ad vetustatem, insequenti volumine exponam.

¹ area *Gr*: gloria aria architecti *H*.

² expolitionibus *S*: expoliationibus *H*.

good, the supervision of the works is approved. But when it has a graceful effect due to the symmetry of its proportions, the site ¹ is the glory of the architect. 10. His work is duly accomplished when he submits to receive advice from his workmen and from laymen. For all men, and not only architects, can approve what is good. But there is this difference between the architect and the layman, that the layman cannot understand what is in hand unless he sees it already done; the architect, when once he has formed his plan, has a definite idea how it will turn out in respect to grace, convenience, and propriety.

I have described, as explicitly as I can, the details which are useful in private buildings and how they are to be carried out. In the next book I will treat of the methods of finishing the work, so that they may be ornamental, free from defects and permanent.

¹ But the conjecture *area* is doubtful.

BOOK VII

LIBER SEPTIMUS

- 1 MAIORES cum sapienter tum etiam utiliter instituerunt, per commentariorum relationes cogitata tradere posteris, ut ea non interirent, sed singulis aetatibus crescentia voluminibus edita gradatim pervenirent vetustatibus ad summam doctrinarum subtilitatem. Itaque non mediocres sed infinitae sunt his agenda gratiae, quod non invidiose silentes praetermiserunt, sed omnium generum sensus conscriptionibus memoriae tradendos curaverunt.
- 2 Namque si non ita fecissent, non potuissemus scire, quae res in Troia fuissent gestae, nec quid¹ Thales, Democritus, Anaxagoras, Xenophanes reliquique physici sensissent de rerum natura, quasque Socrates, Platon, Aristoteles, Zenon, Epicurus aliique philosophi hominibus agenda vitae terminationes finissent, seu Croesus,² Alexander, Darius ceterique reges quas res aut quibus rationibus gessissent, fuissent notae, nisi maiores praeceptorum conparationibus omnium memoriae ad posteritatem commentariis extulissent.
- 3 Itaque quemadmodum his gratiae sunt agenda,

¹ nequid H.

² croessus H.

¹ Vitruvius, probably, has in view (a) histories *commentarii*; (b) collections of opinions, beginning with Theophrastus' *Opinions of Natural Philosophers*.

² Zeno of Citium in Cyprus, probably a Semite, founded the Stoic philosophy so called from the frescoed Colonnade *Stoa*

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BOOK VII

PREFACE

1. OUR predecessors, wisely and with advantage, proceeded by written records to hand down their ideas to after times, so that they should not perish, but being augmented from age to age and published in book form, they should come step by step in the course of time to a complete and accurate body of knowledge. Hence we must render to them more than moderate thanks, indeed the greatest, because they did not let them all go in jealous silence, but provided for the record in writing of their ideas in every kind.¹

2. If they had not done so, we could not have known the history of Troy, nor the natural philosophy of Thales, Democritus, Anaxagoras, Xenophanes, and the rest; nor should we have been acquainted with the precepts of Socrates, Plato, Aristotle, Zeno,² Epicurus, and other philosophers for the conduct of human life, nor with the actions and policy of Croesus, Alexander, Darius, and other monarchs, unless our predecessors in their records and collections of opinions had published these matters to posterity and the memory of the world.

3. While, then, these men deserve our gratitude,

Poikile, at Athens in which he taught. The Peripatetic (Aristotelian) philosophy derived its name from the Cloisters, *peripatoi*, of the gymnasium in which the master taught.

contra,¹ qui eorum scripta furantes pro suis prae-
dicant, sunt vituperandi, quique non propriis cogi-
tationibus scriptorum nituntur, sed invidis moribus
aliena violantes gloriantur, non modo sunt repre-
hendendi,² sed etiam, qui impio more vixerunt,
poena condemnandi. Nec tamen hae res non
vindictae curiosius ab antiquis esse memorantur.
Quorum exitus iudiciorum qui fuerint, non est
alienum, quemadmodum sint nobis traditi, explicare.

4 Regis³ Attalici magnis philologiae dulcedinibus
inducti cum egregiam bybliotheam Pergami ad
communem delectationem instituissent, tunc item
Ptolomaeus infinito zelo cupiditatisque incitatus⁴
studio non minoribus industriis ad eundem modum
contenderat Alexandriae comparare. Cum autem
summa diligentia perfecisset, non putavit id satis
esse, nisi propagationibus in seminando curaret
augendam. Itaque Musis et Apollini ludos dedi-
cavit et, quemadmodum athletarum, sic com-
muniū⁵ scriptorum victoribus praemia et honores
constituit.

5 His ita institutis, cum ludi adessent, iudices litterati,
qui ea probarent, erant legendi. Rex, cum iam sex
civitatis⁶ lectos habuisset nec tam cito septimum
idoneum inveniret, retulit ad eos, qui supra byblio-
thecam fuerunt, et quaesiit, si quem novissent ad

¹ sunt agendaē contra *rec* : sunt agendaest contra *H*.

² repraehendi *H*.

³ regis *H*.

⁴ incitatis *H*.

⁵ siccommuniū *H*.

⁶ excivitatibus *G*.

¹ The Attalid dynasty ruled from 280 B.C. to 133 B.C. Eumenes I (263–241), Attalus I (241–197), Eumenes II (197–159) fostered the library. The building which housed it was erected by Eumenes II.

on the other hand we must censure those who plunder their works and appropriate them to themselves; writers who do not depend upon their own ideas, but in their envy boast of other men's goods whom they have robbed with violence, should not only receive censure but punishment for their impious manner of life. And this practice, as we are informed, was duly dealt with by the ancients. It is not out of place to relate the results of these trials as they have been handed down.

4. The Attalid kings,¹ impelled by their delight in literature, established for general perusal² a fine library at Pergamus. Then Ptolemy, moved by unbounded jealousy and avaricious desire, strove with no less industry to establish a library at Alexandria after the same fashion.³ When he had completed it with great diligence, he did not think it enough unless he should provide for its increase by sowing and planting. So he consecrated games in honour of the Muses and Apollo, and established prizes and honours for the successful writers of the day, in the same way as for successful athletes.

5. When the arrangements were completed, and the games were at hand, learned judges had to be chosen to examine the competitors. When the king had chosen six persons from the city and could not quickly find a seventh⁴ person suitable, he consulted the governors of the library whether

* *delectatio* = *voluptas suavitatis auditus animum deleniens*.
Cic. *Tusc.* IV. 9. 20.

² Ptolemy Philadelphus built two great libraries to contain his collections, completed by his successor, Euergetes.

⁴ In Greek idiom implies six others.

id expeditum. Tunc ei dixerunt esse quendam Aristophanen, qui summo studio summaque diligentia cotidie omnes libros ex ordine perlegeret. Itaque conventu ludorum, cum secretae sedes iudicibus essent distributae, cum ceteris Aristophanes citatus, quemadmodum fuerat locus ei
 6 designatus, sedit. Primo poetarum ordine ad certationem inducto cum recitarentur scripta, populus cunctus significando monebat iudices, quod probarent. Itaque, cum ab singulis sententiae sunt rogatae, sex una dixerunt, et, quem maxime animadverterunt multitudini placuisse, ei primum praemium, insequenti secundum tribuerunt. Aristophanes vero, cum ab eo sententia rogaretur, eum
 7 primum renuntiari iussit, qui minime populo placuisset. Cum autem rex et universi vehementer indignarentur, surrexit et rogando impetravit,¹ ut paterentur se dicere. Itaque silentio facto docuit unum ex his eum esse poetam, ceteros aliena recitavisse; oportere autem iudicantes non furta sed scripta probare. Admirante populo et rege dubitante, fretus memoriae certis armariis infinita volumina eduxit et ea cum recitatis conferendo coegit ipsos furatos de se confiteri. Itaque rex iussit cum his agi furti condemnatosque cum ignominia dimisit, Aristophanen vero amplissimis muneribus ornavit et supra bybliotheecam constituit.

¹ impetravit *rec* : imperavit *H*.

¹ Aristophanes the critic 257–180 B.C. The reign of Euergetes (*ob.* 222) fits in with the story.

² Aristophanes probably worked in the library many years before he succeeded Eratosthenes as head.

³ Probably Ptolemy III Euergetes.

⁴ *Armarium*, sometimes recess in wall of library as at Timgad.

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they knew anyone prepared for such a duty. They gave the name of Aristophanes,¹ who read each book in the library systematically day by day with comprehensive ardour and diligence. Therefore at the assemblage for the games special seats were allotted to the judges, and Aristophanes, being summoned with the rest, took his seat in the place allotted to him. 6. The competition for poets was first on the list; and when their poems were recited, the whole multitude by its utterances warned the judges what to approve. When, therefore, the judges were asked one by one, the six agreed and gave the first prize to the poet who, they observed, most pleased the audience; the second prize to the person who came next in their approval. Aristophanes,² however, when his opinion was asked, voted that the first place should be given to the candidate who was least liked by the audience. 7. When the king³ and all the company showed great indignation, he rose and obtained permission to speak. Amid a general silence he informed them that only one of the competitors was a true poet; the others recited borrowed work, whereas the judges had to deal with original compositions, not with plagiaries. The assembly were surprised and the king was doubtful. Aristophanes relying upon his memory produced a large number of papyrus rolls from certain bookcases,⁴ and comparing these with what had been recited he compelled the authors to confess they were thieves. The king then ordered them to be brought to trial for theft. They were condemned and dismissed in disgrace, while Aristophanes was raised to high office and became librarian.⁵

⁵ c. 195 B.C.

- 8 Insequentibus annis a Macedonia¹ Zoilus, qui adoptavit cognomen, ut Homeromastix vocitaretur, Alexandriam venit suaque scripta contra Iliadem et Odyssean² comparata regi recitavit. Ptolomaeus vero, cum animadvertisset poetarum parentem philologiaeque omnis ducem absentem vexari et, cuius ab cunctis gentibus scripta suspicerentur, ab eo vituperari, indignans³ nullum ei dedit responsum. Zoilus autem, cum diutius in regno fuisset, inopia pressum⁴ remisit ad regem postulans, ut aliquid
 9 sibi tribueretur. Rex vero respondisse dicitur Homerum, qui ante annos mille decessisset, aevo perpetuo multa milia hominum pascere, item debere, qui meliore ingenio se profiteretur, non modo unum sed etiam plures alere posse. Et ad summam mors eius ut parricidii damnati varie memoratur. Alii enim scripserunt a Philadelpho esse in crucem fixum, nonnulli Chii⁵ lapides esse coniectos, alii Zmyrnae vivum in pyram coniectum. Quorum utrum ei acciderit, merenti digna constitit poena; non enim aliter videtur promereri, qui citat eos, quorum responsum, quid senserint scribentes, non potest coram indicari.
- 10 Ego vero, Caesar, neque alienis indicibus mutatis interposito nomine meo id profero corpus neque ullius cogitata vituperans institui ex eo me adprobare, sed omnibus scriptoribus infinitas ago gratias, quod egregiis ingeniorum sollertiis ex aevo conlatis

¹ macedonia *H.*

² iliaden et odissian *H.*

³ indignans *G.*; indignus *H S.*

⁴ pressum remisit *H S.*: sc. se esse.

⁵ Chii *Salmasius*: chiei *H G.*

8. Some years after, Zoilus, who had taken a surname so as to be called the Scourge of Homer, came from Macedonia to Alexandria, and read his works directed against the *Iliad* and *Odyssey*. Ptolemy, however, observed that the father of poets and the founder of literature was attacked in his absence, and that Zoilus abused one whose works were looked up to by all nations, and in his indignation would not reply to him. Zoilus, however, remaining some time in Egypt, was overcome by poverty and submitted his name to the king for an allowance. 9. The king is said to have replied that Homer, whose death occurred many years before, had through all that age of time furnished a livelihood to many thousands; a man, therefore, who claimed to be of a finer talent should be able to maintain not only one but many others as well. In fine, Zoilus was condemned for parricide, and his death is variously recorded. Some have written that he was crucified by Philadelphus;¹ others that he was stoned at Chios; others that he was thrown alive on a burning pyre in Smyrna. Whichever happened to him, the penalty fitted the culprit. Such seems to be the desert of a man who calls into court those who can no longer reply publicly, when asked what they meant by their writings.

10. But this encyclopaedia, your Highness, is not presented under my own name with the suppression of my authorities, nor have I set out to gain approbation by vituperating any man's ideas. For I owe great gratitude to all those who with an ocean of intellectual services which they gathered from all

¹ This statement supports the currency of the anecdote, and suggests that the critic was not identical with the orator.

abundantes alius ¹ alio genere copias praeparaverunt, unde nos uti fontibus haurientes aquam et ad propria proposita traducentes facundiores et expeditiores habemus ad scribendum facultates talibusque confidentes auctoribus audemus institutiones novas comparare.

- 11 Igitur tales ingressus eorum quia ² ad propositi mei rationes animadverti praeparatos, inde sumendo progredi coepi. Namque primum Agatharchus ³ Athenis Aeschylō docente tragoediam ad scaenam fecit,⁴ et de ea commentarium reliquit. Ex eo moniti Democritus et Anaxagoras de eadem re scripserunt, quemadmodum oporteat, ad aciem oculorum radiorumque extentionem ⁵ certo loco centro constituto, ad lineas ratione naturali respondere, uti de incerta re incertae imagines ⁶ aedificiorum in scaenarum picturis redderent speciem et, quae in directis planisque frontibus sint figurata, alia abscedentia, alia prominentia esse videantur.
- 12 Postea Silenus de symmetriis doricorum edidit volumen; de aede ionica Iunonis quae est Sami Rhoecus et ⁷ Theodorus; ionice Ephesi quae est

¹ alius *Oudendorp*: aliis *H.* ² quia *Ro*: quae *H.*

³ agatharchus *G.*, -tarcus *H S.*

⁴ ad scaenam fecit *e₂*, *ed*: *Athenis architectus praecerat Dionysiis.*

⁵ extentione *H S.*

⁶ incerta re incertae imagines *h*: incerta rem *c* fortasse ex incerta re *H.*

⁷ *text. Gr*: de aede iōnonis quae est Samii dorica zeodorus *H, C.R. 1924, 112.*

¹ *Institutiones* = manual.

time, each in his department provided stores from which we, like those who draw water from a spring and use it for their own purposes, have gained the means of writing with more eloquence and readiness; and trusting in such authorities we venture to put together a new manual¹ of architecture.

11. Because, then, I observed that such beginnings had been made towards the method of my undertaking, I drew upon these sources and began to go forward. For to begin with: Agatharchus² at Athens, when Aeschylus was presenting a tragedy, was in control of the stage, and wrote a commentary about it. Following his suggestions, Democritus³ and Anaxagoras³ wrote upon the same topic, in order to show how, if a fixed centre is taken for the outward glance of the eyes and the projection of the radii, we must follow these lines in accordance with a natural law, such that from an uncertain object, uncertain images may give the appearance of buildings in the scenery of the stage, and how what is figured upon vertical and plane surfaces can seem to recede in one part and project in another.⁴

12. Subsequently Silenus⁵ published a work upon Doric proportions; Rhoecus and Theodorus⁶ on the Ionic temple of Juno which is at Samos;

² Agatharchus, son of Eudemus, of Samos. By introducing perspective, he revolutionised Greek paintings; cf. *Plat. Rep.* X. 602. The play was the trilogy of the *Oresteia*.

³ Previously mentioned together, VII. *pref.*

⁴ For the text and interpretation of this passage, see my article *The Parthenon and the Baroque*, *J.R.I.B.A.* 1931, 755 ff.

⁵ Not otherwise known.

⁶ Rhoecus and Theodorus worked together, *Plin. N.H.* XXXV. 152.

Dianae, Chersiphron¹ et Metagenes; de fano Minervae, quod est Prienae ionicum, Pytheos;² item de aede Minervae, dorice quae est Athenis in arce, Ictinos³ et Carpion; Theodorus Phocaeus de tholo, qui est Delphis; Philo de aedium sacrarum symmetriis et de armamentario,⁴ quod fuerat Piraei portu; Hermogenes de aede Dianae, ionice quae est Magnesia pseudodipteros, et Liberi Patris Teo⁵ monopteros;⁶ item Arcesius⁷ de symmetriis corinthiis et ionico Trallibus Aesculapio, quod etiam ipse sua manu dicitur fecisse; de Mausoleo Satyrus et Pytheos.⁸

- 13 Quibus vero felicitas maximum summumque contulit munus; quorum enim artes aevo perpetuo nobilissimas laudes et sempiterno florentes habere iudicantur, et cogitatis egregias operas praestiterunt. Namque singulis frontibus singuli artifices⁹ sumpserunt certatim partes ad ornandum et probandum Leochares, Bryaxis, Scopas,¹⁰ Praxiteles, nonnulli etiam putant Timotheum, quorum artis eminens

¹ cersiphon *H.*

² Pytheos *Schn*: phyleos *H S.*

³ ictionos *H.*

⁴ armamentario *ed*: armentario *H.*

⁵ Teo *Joc*: &eo *H S.*, et eo *G.*

⁶ monopteros *G*: monocteros *H S.*

⁷ Arcesius *Ro*: argelius *H.*

⁸ saturus *H*: phiteus *H.*

⁹ singulis artifices *H.* ¹⁰ scaphas *H.*

¹ Robertson, *Greek and Roman Architecture*, 94 n.

² Robertson, 148.

³ Lethaby, *Greek Buildings*, 83.

⁴ Robertson, 141. ⁶ Lethaby, 208.

⁸ Specification recorded C.I.A. II. 1054.

Chersiphron and Metagenes on the Ionic temple of Diana which is at Ephesus¹; Pythius on the temple of Minerva in the Ionic style which is at Priene;² Ictinus³ and Carpion on the Doric temple of Minerva which is on the Acropolis at Athens; Theodorus⁴ of Phocaea on the Tholos at Delphi; Philo⁵ <of Eleusis> on the proportions of temples and the arsenal⁶ which was in the harbour of the Piraeus; Hermogenes⁷ on the pseudodipteral Ionic temple of Diana⁸ at Magnesia and the monopteral temple of Father Bacchus⁹ at Teos; Arcesius on Corinthian proportions, and the Ionic temple at Tralles¹⁰ to Aesculapius, whose image is said to have been carved by him; Satyrus and Pythius on the Mausoleum.¹¹

13. And on these last, good fortune conferred the greatest and highest boon. For their works are adjudged to have a merit which is famous throughout the ages and of unfading freshness¹² and they employed distinguished artists on their undertakings. For on the several elevations, different rival craftsmen took their share in decorations wherein they competed: Leochares,¹³ Bryaxis,¹⁴ Scopas,¹⁵ Praxiteles,¹⁶ and some add Timotheus.¹⁷ The out-

⁷ Book III. iii. 8.

⁸ Robertson, 155.

⁹ Robertson, 157.

¹⁰ Ruins described; Fellows, *Asia Minor*, 276.

¹¹ Lethaby, 37 ff.

¹² This eternal freshness was specially attributed to the structures of Pericles, Plut. *vit.* XIII.

¹³ Book II. viii. 11, Plin. *N.H.* XXXVI. 31.

¹⁴ Plin. *N.H.* XXXIV. 73.

¹⁵ Works distinguished by intense expression.

¹⁶ The exquisite finish of his works: Athen. XIII. 591.

¹⁷ Book II. viii. 11; carved draperies very finely.

excellencia coegit ad septem spectaculorum eius operis pervenire famam.

- 14 Praeterea minus nobiles multi praecepta symmetriarum conscripserunt, uti Nexaris, Theocydes,¹ Demophilos, Pollis, Leonidas,² Silanion, Melampus, Sarnacus, Euphranor. Non minus de machinationibus, uti Diades, Archytas, Archimedes, Ctesibios,³ Nymphodorus, Philo Byzantius,⁴ Diphilos,⁵ Democles, Charias,⁶ Polyidos, Pyrrhos,⁷ Agesistratos.⁸ Quorum ex commentariis, quae utilia esse his rebus animadverti, [collecta in unum coegi corpus, et ideo maxime, quod animadverti]⁹ in ea re ab Graecis volumina plura edita, ab nostris oppido quam pauca. Fufidius¹⁰ enim mirum de his rebus primus instituit edere volumen, item Terentius Varro de novem disciplinis unum de architectura, P. Septimius duo.
- 15 Amplius vero in id genus scribaturae adhuc nemo incubuisse videtur, cum fuissent et antiqui cives magni architecti, qui potuissent non minus eleganter scripta comparare. Namque Athenis Antistates et

¹ theocides *H S.*

² leonidas *G*: -des *H S.*

³ &esibios *H S.*, et esibios *G.*

⁴ phylobyzanteos *H S.*

⁵ diphylos *H S.*

⁶ charidas *H.*

⁷ phyrros *H.*

⁸ agesistratas *H.*

⁹ collecta—animadverti *G*: *om. H S.*

¹⁰ Fufidius *Schn*: Fuficius *H.*

¹ Book II. viii. 11.

² Painter, master of Zeuxis, *Plin. N.H. XXXV. 61.*

³ Painter, *Plin. N.H. XXXIV. 91.*

⁴ Made portrait statues, *Plin. N.H. XXXIV. 81.*

⁵ Painter and sculptor, and writer: type of versatile genius.

⁶ Book X. xiii. 3. Polyidos and Diades are named in a list of *mechanici* in a papyrus of about 100 B.C. *Pap. Berol. P. 13044.*

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standing excellence of their work caused the fame of the Mausoleum to be included in the seven wonders¹ of the world.

14. In addition to these, many men of less fame have compiled the rule of symmetry, such as Nexaris, Theocydes, Demophilus,² Pollis,³ Leonidas, Silanion,⁴ Melampus of Sarnaca, Euphranor.⁵ Others have written on machinery: Diades,⁶ Archytas,⁷ Archimedes,⁸ Ctesibius,⁹ Nymphodorus,¹⁰ Philo of Byzantium,¹¹ Diphilus,¹² Democles,¹³ Chaerias,⁶ Polyidus,⁶ Pyrrhus,¹⁴ Agesistratus. As to the useful contributions to our subject which I found in their commentaries, many volumes have been published by the Greeks, exceedingly few by our own writers. For Fufidius¹⁵ curiously enough was the first to publish a volume on these topics. Further, Varro included one volume in his work *On the Nine Disciplines*¹⁶; Publius Septimius¹⁷ wrote two volumes.

15. Up to now no one seems to have gone further in this kind of writing, although our citizens of old have been great architects who might have compiled works of equal precision. For at Athens the archi-

⁷ Book I. i. 17.

⁸ Book I. i. 7, 17.

⁹ Book IX. viii. 2; I. i. 7.

¹⁰ "Inventor of scientific toys." Athen. I. 19.

¹¹ Wrote on 'mechanics,' contemporary of Ctesibius.

¹² Perhaps architect to Quintus Cicero. Cic. *Q. Fr.* III. 1. 1.

¹³ Plin. *N.H.* XXXIV., XXXV. in list of authorities; Strabo I. 58.

¹⁴ Wrote on siege engines, Athen. *Math. Vett.* 2.

¹⁵ Probably a friend of Cicero, *Fam.* XIII. xi. 3, and aedile at Arpinum, Wilm. 2050.

¹⁶ Encyclopædia of Education.

¹⁷ Quaestor of Varro who dedicated to him first three books, *de lingua Latina*.

Callaeschros¹ et Antimachides et Porinos² architecti Pisistrato aedem Iovi Olympio facienti fundamenta constituerunt, post mortem autem eius propter interpellationem reipublicae³ incepta reliquerunt. Itaque circiter annis quadringentis⁴ post Antiochus rex, cum in id opus inpensam esset pollicitus, cellae magnitudinem et columnarum circa dipteron conlocationem epistyliorumque et ceterorum ornamentorum ad symmetriam distributionem magna sollertia scientiaque summa civis Romanus Quosutius⁵ nobiliter est architectatus. Id autem opus non modo volgo, sed etiam in paucis a magnificentia nominatur.

- 16 Nam quattuor locis sunt aedium sacrarum marmoreis operibus ornatae dispositiones, e quibus propriae de his nominationes clarissima fama nominantur quorum excellentiae prudentesque⁶ cogitationum apparatus suspectus habent in deorum *sesemasmeno*s.⁷ Primumque aedes Ephesi Dianae ionico genere ab Chersiphronē⁸ Gnosio et filio eius Metagene⁹ est instituta, quam postea Demetrius, ipsius Dianae servos, et Paeonius Ephesius dicuntur perfecisse. Mileti¹⁰ Apollini item ionicis symmetriis idem Paeonius Daphnisque¹¹ Milesius instituerunt. Eleusine Cereris¹² et Proserpinae cellam inmani

¹ callescheros *H S.* ² porinos *G*: pormos *H S.*

³ reipublice *G S*: regi publice *H.*

⁴ quadringentis *Meurs.*: ducentis *H.*

⁵ quosutius *H*: quossutius *H.* ⁶ prudentis *H S.*

⁷ sesemasmeno *Gr*: sesemaneo *H G*, cf. Plato, *Legg.* 954a.

⁸ ab chersiphronē *H.* ⁹ metagine *H S.*

¹⁰ meleti *H.* ¹¹ daphnis *G*: daphinis *H S.*

¹² cereris *G S*: ca&eris *H.*

¹ These names may have been taken from an inscription.

² The correction *quadringentis* for *ducentis* seems necessary.

fects ¹ Antistates and Callaeschrus and Antimachides and Porinus laid the foundations for Pisistratus when he was building a temple to Olympian Jupiter. After his death they abandoned his undertaking because of the interruption caused by the republic. About four hundred ² years after, king Antiochus undertook the cost of the building. A Roman citizen Cossutius, an architect of great skill and scientific attainments, finely designed the great sanctuary with a double colonnade all round and with the architrave symmetrically disposed. And this building is famous owing to its magnificence not only with the crowd but with the experts.

16. For in four places temples have been erected and finished with marble, whence their names are current and most renowned. Their fine character and the skilful management of their design gains a high regard among the chefs-d'œuvre of religion.³ First of all the temple of Diana ⁴ at Ephesus was planned in the Ionic style by Chersiphron of Cnossus and his son Metagenes; afterwards Demetrius, a temple warden ⁵ of Diana, and Paeonius ⁶ of Ephesus are said to have completed it. At Miletus the same Paeonius, and Daphnis of Miletus, built for Apollo ⁷ in the Ionic style. At Eleusis, Ictinus ⁸ built the temple of Ceres and Proserpine in the Doric manner,

³ Lit. "sealed." Treasures of the gods were sealed.

⁴ *Ante*, 12.

⁵ Ordinarily *aedituos* = Gk. *neokoros*; cf. *Acts* xix. 35: *neokoros polis*.

⁶ Lethaby, 34.

⁷ Didymaeum; the former temple was burnt by Darius 496 B.C.; this, the new temple, scarcely less than the Artemisium at Ephesus, was never finished.

⁸ His subordinate architects are enumerated, *Plut. Pericles*, 13.

magnitudine Ictinos dorico more sine exterioribus columnis ad laxamentum usus sacrificiorum pertexit.

- 17 Eam¹ autem postea, cum Demetrius Phalereus Athenis rerum potiretur, Philo ante templum in fronte columnis constitutis prostylon fecit; ita aucto vestibulo laxamentum initiantibus² operique summam adfecit auctoritatem. In asty vero ad Olympium amplo modulorum comparatu corinthiis symmetriis et proportionibus, uti s.s. est,³ architectandum Quossutius⁴ suscepisse memoratur, cuius commentarium nullum est inventum. Nec tamen a Cossutio solum de his rebus scripta sunt desideranda sed etiam a G. Mucio,⁵ qui magna scientia confusus aedes Honoris et Virtutis Marianae,⁶ cellae columnarumque et epistylorum symmetrias legitimis artis institutis perfecit.⁷ Id vero si marmoreum fuisset, ut haberet, quemadmodum ab arte subtilitatem, sic ab magnificentia et inpensis auctoritatem, in primis et summis operibus nominaretur.

- 18 Cum ergo et antiqui nostri inveniantur non minus quam Graeci fuisse magni architecti et nostra memoria satis multi, et ex his pauci praecepta edidissent, non putavi silendum, sed disposite singulis voluminibus de singulis exponeremus. Itaque, quoniam sexto⁸ volumine privatorum aedificiorum rationes perscripsi, in hoc, qui septimum tenet numerum, de expolitionibus, quibus rationibus et venustatem et firmitatem habere possint, exponam.

¹ eam ed: ea H G.

² initiantibus G: initientibus H S.

³ uti s.s. est H: uti cc ð e, cum schol. 'pro notis s.s. e. ut in Blandiniano.' Hae notae in h: cf. Vol. I. xxiii.

⁴ cossutius G S: quossutius H¹.

⁵ A. G. mutio H S.

⁶ marinianae H S.

⁷ perficit H.

⁸ sexto H²: secto H.

and of an immense size without exterior columns; it was covered in to afford a convenient space for sacrifice.

17. When Demetrius of Phaleron was master of Athens,¹ Philo² erected columns in front before the temple and turned it into a prostyle building. Thus by enlarging the approach he gave space for the initiates and great impressiveness to the building. In the city the Olympeum was designed with Corinthian symmetries and proportions and an ample module by the architect Cossutius, as already described.³ No specification by him is extant. Not only do we miss such a work from Cossutius but also from Gaius Mucius,⁴ who,—in the temple of Honour and Virtue erected by Marius,—relying upon his scientific acquirements, finished off the symmetries of the sanctuary, the columns and the entablature, in accordance with the legitimate rules of art. But if it had been of marble so as to be impressive by a costly magnificence, no less than marked by a skilful precision, it would have a name among the buildings of the first and highest class.

18. While, therefore, our predecessors are found, no less than the Greeks, to have been great architects, and sufficiently many in our own time, few of them have published their methods. Hence I thought we ought not to remain silent, but we should set forth methodically the various branches of the subject in separate volumes. Therefore, after describing in the sixth book the arrangements of private buildings, in this book, which is the seventh, I will explain how they are finished in such a way as to combine durability with elegance.

¹ 317–307 B.C.

² *Ante*, 12.

³ *Ante*, 15.

⁴ Book III. ii. 5.

I

1 PRIMUMQUE incipiam de ruderatione, quae principia tenet expolitionum, uti curiosius summaque providentia solidationis ratio habeatur. Et si plano pede erit eruderandum, quaeratur, solum¹ si sit perpetuo solidum, et ita exaequetur, et inducatur cum statumine rudus. Sin autem omnis aut ex parte congesticius² locus fuerit, fistucationibus cum magna cura solidetur. In contignationibus vero diligenter est animadvertendum, ne qui paries, qui non exeat ad summum, sit extructus sub pavementum, sed potius relaxatus supra se pendentem habeat coaxationem. Cum enim solidus exit, contignationibus arescentibus aut pandatione sidentibus,³ permanens structurae soliditate dextra ac sinistra secundum se facit in pavementis necessario rimas.

2 Item danda est opera, ne commisceantur axes aesculini quercu, quod quercei,⁴ simul umorem perceperunt, se torquentes rimas faciunt in pavementis. Sin autem aesculus non erit et necessitas coegerit propter inopiam, querceis⁵ sic videtur esse faciendum, ut secentur tenuiores; quo minus⁶ enim valuerint, eo facilius clavis⁷ fixi continebuntur. Deinde in singulis tignis extremis partibus axis bini clavi figantur, uti nulla ex parte possint se torquendo anguli excitare. Namque de cerro aut fago seu farno nullus ad vestutatem potest permanere.

¹ non solum *ante ras. H.*

² coniesticius *H S.*

³ sedentibus *H.*

⁴ quercui *H G.*

⁵ quaercis *H*, quercis *G S.*

⁶ minus *H.*

⁷ clavis *G*: clavi *H S.*

¹ *quercus aesculus, II. ix. 9.*

² *quercus robur, II. ix. 8.*

CHAPTER I

ON PAVEMENTS

1. FIRST, I will begin with rubble paving, which is the first stage in finishing, so that account may be taken, with special care and great foresight, of a solid foundation. If we must carry out our paving on level ground we must inquire whether the soil is solid throughout; it is then to be levelled, and rubble must be spread over the surface. But if there is a made site, in whole or in part, it must be rammed very carefully with piles. In the case of upper floors great attention must be given, lest any wall in the story below is built right up to the pavement; it is rather to stop short and have the joists carried free above it. For when the wall is taken up solid, if the flooring above dries or sags as it settles, the wall being of a solid structure, necessarily causes cracks, right and left of it, in the pavements above.

2. Attention must also be given not to mix planks of winter oak¹ with common oak.² For common oak, when it becomes moist, warps and makes cracks in the pavement. But if there is no winter oak and need drives, we must work with common oak, using thin planks. For the weaker they are, the more easily will they be kept in their place by nails. Then two nails are to be driven in each joist at the edges of the plank, so that the corners of the planks may not warp and rise up. No plank of Turkey oak,³ beech, or ash⁴ can remain durable.

¹ *quercus cerris*, II. ix. 9.

² *farnus*, probably a technical word.

Coaxationibus factis, si erit, flex, si non, palea substernatur, uti materies ab calcis vitiis defendatur.

- 3 Tunc insuper statuminetur ne minore saxo, quam qui possit manum implere. Statuminationibus inductis,¹ rudus si novum erit, ad tres partes una calcis misceatur, si redivivum fuerit, quinque ad duum mixtiones habeant responsum. Deinde rudus² inducatur et vectibus ligneis, decuriis inductis, crebriter pinsatione³ solidetur, et id non minus pinsum absolutum crassitudine sit dodrantis. Insuper ex testa nucleus⁴ inducatur mixtionem habens ad tres partes unam calcis, ne minore crassitudine pavementum digitorum senum. Supra nucleum ad regulam et libellam exacta pavimenta struantur sive
- 4 sectilia seu tesseris. Cum ea exstructa fuerint et fastigia sua exstructionem habuerint, ita fricentur, uti, si sectilia sint, nulli gradus in scutulis aut trigonis aut quadratis seu favis extent, sed coagmentorum compositio planam habeat inter se deredectionem, si tesseris structum erit, ut eae omnes angulos habeant aequales; cum enim anguli non fuerint omnes aequaliter pleni, non erit exacta, ut oportet, fricatura. Item testacea spicata tiburtina sunt diligenter exigenda, ut ne habeant lacunas nec extantes tumulos, sed extenta et ad regulam perfricata. Super fricaturam, levigationibus et polituris cum fuerint perfecta, incernatur marmor, et supra loricae ex calce et harena inducantur.

¹ inductis *ed*: -tus *H*.

² inrudus *H*.

³ pinsatione *G*: piscatione *H S*.

⁴ nucleos *H*.

¹ *Decuriae* of labourers, usually of slaves, Sen. *Ep.* 47, 9.

² *Opus signinum* made of potsherds and lime, used at Pompeii for pavements.

After finishing the flooring, fern—if you have it—or else straw, is to be spread over, so that the wood may be protected against the injury caused by lime.

3. Next a layer of stones is to be spread, each of which is not less than a handful. After spreading the stones, the rubble, if it is fresh, is to be mixed, three parts to one of lime; if it is of old materials, five parts of rubble are to be mixed with two of lime. Let it then be laid on, and rammed down with repeated blows by gangs¹ of men using wooden stamps. When the stamping is finished, it must be not less than nine inches thick. Upon this, a hard coat of powdered pottery is to be laid, three parts to one of lime, forming a layer of six inches.² On the finishing coat, a pavement³ of marble slabs or of mosaic is to be laid to rule and level. 4. When it is laid, and the proper fall is adjusted, it is to be rubbed down; so that, if the pavement is of marble, no projecting edges may arise in the diamonds or triangles or squares or hexagons;⁴ but the adjustment of the joints is to be level one with another. If it is mosaic, the edges of the tesserae are all to be level. For when the edges are not even, the rubbing down will be imperfect. So also Tiburtine tiles⁵ laid herring-bone fashion, are to be carefully handled so that they do not present gaps or ridges, being spread out and rubbed to a level. After the rubbing down, when they are completely smoothed and finished, marble dust is sprinkled over, and over that coats of lime and sand are to be applied.

¹ Caesar took with him on his campaigns the materials for paving his headquarters with mosaics and marble, Suet. *Vit.* 46.

² *Opus sectile* in marble in geometric forms.

³ Philander, *ad loc.*, reports them in the villas of Vopiscus and Hadrian at Tivoli.

- 5 Subdiu vero maxime idonea faciunda sunt pavimenta, quod contignationes umore crescentes aut siccitate decrescentes seu pandationibus sidentes¹ movendo se faciunt vitia pavimentis; praeterea gelicidia et proinae² non patiuntur integra permanere. Itaque si necessitas coegerit, ut minime vitiosa fiant, sic erit faciundum. Cum coaxatum fuerit, super altera coaxatio transversa sternatur clavisque fixa duplicem praebeat contignationi loricationem. Deinde ruderi novo tertia pars testae tunsae admisceatur, calcisque duae partes ad quinque mortarii mixtionibus praestent responsum.
- 6 Statuminatione facta rudus inducatur, idque pistum absolutum ne minus pede sit crassum.³ Tunc autem nucleo inducto, uti s. s. est, pavementum e tessera grandi circiter binûm digitûm caesa struatur fastigium habens in pedes denos digitos⁴ binos; quod si bene temperabitur et recte fricatum fuerit, ab omnibus vitiis erit tutum. Uti autem inter coagmenta materies ab gelicidiis ne laboret, fracibus⁵ quotannis⁶ ante hiemem saturetur; ita non patietur in se recipere gelicidii pruina.
- 7 Sin autem curiosius videbitur fieri oportere, tegulae bipedales inter se coagmentatae supra rudus substrata materia conlocentur habentes singulis coagmentorum frontibus excelsos canaliculos digitales. Quibus iunctis inpletur calx ex oleo subacta, confricenturque inter se coagmenta compressa. Ita calx, quae erit haerens in canalibus, durescendo [contestateque solidescendo]⁷ non patietur aquam

¹ sedentes *H.*² proinae *H*: vera lectio apud *Kr.* qui hic, ut alibi, *Ro* correxit.³ grassum *H.*⁴ digitus *H S.*⁵ fragibus *H.*⁶ quodannis *H.*

5. Such pavements are most suitable to be used in the open. For wood floors swell with damp, or shrink in dry weather, or sag and settle, and make faulty pavements by giving way. Besides, ice and hoar-frost hinder their durability. But if need compels, we must limit their failure as far as possible in the following manner. After laying the floor, a second floor is to be laid above cross-wise; being fixed with nails, it will furnish a double coating to the joists. Then a third part of broken pottery is to be mixed in the fresh rubble, and two parts of lime are to answer to five¹ when mixed in the mortar.

6. Let the ground be spread with this, and the rubble be laid over it and pounded thoroughly to a thickness of not less than a foot. Then the finishing coat is to be put on as already described, and the pavement is to be laid with tesserae about two inches thick, with a fall of two inches in ten feet. If this is well mixed and properly rubbed over, it will be safe against all damage. That the mortar between the joints may not be affected by the frost, let it be soaked every year with oil lees before the winter. In this way it will not take up the frost into itself.

7. But if special care seems to be needed, tiles two feet square jointed together are to be laid upon the pavement of mortar, with small channels an inch deep on each side. When these are joined, lime tempered with oil is to be filled in, and the joints are to be pressed together and rubbed down. Thus the lime which will remain in the channels will harden and prevent water or anything else from passing

¹ *I.e.* One part potsherds, two parts rubble, two parts lime.

⁷ *contestateque solidiscendo G. om. H S, del. G^a.*

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neque aliam rem per coagmenta transire. Cum ergo fuerit hoc ita perstratum, supra nucleus¹ inducatur et virgis caedendo subigatur. Supra autem sive ex tessera grandi sive ex spica² testacea struantur fastigiis, quibus est supra scriptum, et cum sic erunt facta, non cito vitiabuntur.

II

- 1 Cum a pavimentorum cura discessum fuerit, tunc de albariis operibus est explicandum. Id autem erit recte, si glaebae calcis optimae ante multo tempore, quam opus fuerit, macerabuntur, uti, si qua glaeba parum fuerit in fornace cocta, in maceratione diuturna liquore defervere coacta uno tenore³ concoquatur. Namque cum non penitus macerata sed recens sumitur, cum fuerit inducta habens latentes crudos calculos, pustulas emittit. Qui calculi, in opere uno tenore cum permacerantur, dissolvunt et
2 dissipant tectorii politiones. Cum autem habita erit ratio macerationis et id curiosius opere praeparatum erit, sumatur ascia et, quemadmodum materia dolatur, sic calx in lacu macerata ascietur. Si ad eam offenderint calculi, non erit temperata; cumque siccum et purum ferrum educetur, indicabit eam evanidam et siticulosam; cum vero pinguis fuerit et recte macerata, circa id ferramentum uti glutinum haerens omni ratione probabit esse temperatam.

¹ nucleus *H.*

² expica *H., om. G.*

³ tenore *Joc* : tempore *H.*

¹ The Roman stucco-work is unusually fine, and has preserved the fresco-paintings in a remarkable manner.

through the joints. When this has so been laid, the first finishing coat is to be spread, beaten with staves and so kneaded. Upon this, are to be put the pavements of thick tesserae or of tiles laid herringbone, with the fall already described, and when this is done, damage will not quickly arise.

CHAPTER II

ON THE PREPARATION OF STUCCO

1. We now pass from the preparation of pavements to plasterers' ¹ work. It will be necessary to obtain lumps of the best lime and crush it long before it is required; so that if any lump be imperfectly burnt in the kiln, owing to the long crushing, it is forced by the moisture to lose its heat and is tempered to an even quality. For when it is applied fresh and not thoroughly slaked; if, without due care it is spread containing rough lumps, it causes blisters. And these lumps of lime, when they get a thorough slaking after the work is begun, break up and destroy the surface of the stucco. 2. Now when attention is given to the slaking and care is taken in preparing the work, a trowel ² is to be taken and the lime which is being slaked in the pit is to be chopped as one chops wood. If lumps are met in the chopping, the lime is not slaked. When the trowel is drawn out dry and clean, it shows that the lime is poor and absorbent; when, however, the lime is rich and duly slaked, it clings round the tool like glue, and shows that it is properly mixed. Then

* Neuburger, 407.

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Tunc autem machinis comparatis camerarum dispositiones in conclavibus expédiantur, nisi lacunariis ea fuerint ornata.

III

- 1 Cum ergo camerarum postulabitur ratio, sic erit faciunda. Asseres directi disponantur inter se ne plus spatium habentes pedes binos, et hi maxime cupressei,¹ quod abiegni ab carie et ab vetustate celeriter vitiantur. Hique asseres, cum ad formam circinationis² fuerint distributi, catenis dispositis ad contignationes, sive tecta erunt,³ crebriter⁴ clavis ferreis fixi religentur. Eaeque catenae ex ea materia comparentur, cui nec caries nec vetustas nec umor possit nocere, id est e buxo, iunipero, olea, robore, cupresso ceterisque similibus praeter quercum, cum ea se⁵ torquendo rimas faciat⁶ quibus inest operibus.
- 2 Asseribus dispositis tum tomice ex⁷ sparto hispanico harundines graecae tunsae ad eos, uti forma postulat, religentur. Item supra cameram materies ex calce et harena mixta subinde inducatur, ut, si quae stillae⁸ ex contignationibus aut tectis ceciderint, sustineantur. Sin autem harundinis graecae copia non erit, de paludibus tenues colligantur⁹ et mataxae tomice¹⁰ ad iustam longitudinem una crassi-

¹ cupraessi *H.*

² circinationes *H S.*

³ tecta erunt *G*: tecter *H.*

⁴ crebiter *H.*

⁵ ea se *Joc*: eas *H.*

⁶ faciat *Joc*: faciant *H S.*

⁷ tomice ex *Joc*: tomices *H S G**, tonices *G.*

⁸ qua est ille *H.*

⁹ colligantur *G S**: -gatur *H S.*

¹⁰ tomicae *H.*

¹ Cicero watched over the work at his brother Quintus' country houses. He approved the pavements but not all the

the scaffolding is to be made ready, and the curved ceilings of the apartments are to be executed, unless they have straight panelled ceilings.

CHAPTER III

ON STUCCO

1. WHEN, therefore, curved ceilings¹ are in question, we must proceed as follows. Parallel laths are to be put not more than two feet apart. They are to be of cypress wood; deal is soon affected by decay and by age. The laths being fixed to the shape of an arch, are to be secured by wooden ties² to the floor or roof above, and fastened with an abundance of iron nails. The ties are to be of timber unaffected by decay or age or damp, such as box-wood, juniper, olive, winter oak, cypress and the like, except the common oak, which warps and causes cracks where it is used.

2. When the ribs are in their place, Greek reeds are to be bruised and bound to the ribs with cords of Spanish broom as the shape of the curve requires. Further, on the upper surface of the arch, mortar, mixed with lime and sand, is to be spread, so that if any drippings fall from the floor or roof above, they may be held up. If there be no supply of Greek reed, thin reeds are to be collected from the marshes, and are to be made up in bundles with cords of rough thread³ to the right length and of equal

arched ceilings. One to which he gave the name *testudo* had a fine curve. Cf. *Q. Fr.* III. 1.

² *catena* = wooden tie, Cato, *R. R.* xviii. 9.

³ *Mataxa*, Schol. Ar. *Ran.* 586.

tudine alligationibus temperentur, dum ne plus inter duos¹ nodos alligationibus binos pedes distent, et hae ad asseres, uti supra scriptum est, tomice² religentur cultellique lignei in eas configantur. Cetera omnia, uti supra scriptum est, expediantur.

3 Cameris dispositis et intextis imum caelum earum trullissetur, deinde harena derigatur, postea autem creca aut marmore poliat.

Cum camerae politae fuerint, sub eas coronae sunt subiciendae, quam maxime tenues et subtilis oportere fieri videbitur; cum enim grandes sunt, pondere deducuntur nec possunt se sustinere. In hisque minime gypsum debet admisceri, sed excepto³ marmore uno tenore perducere, uti ne praecipiendo non patiatur uno tenore opus inarescere. Etiamque cavendae sunt in cameris priscorum dispositiones, quod earum planitiae coronarum gravi pondere

4 inpendentes sunt periculosae. Coronarum autem sunt figurae aliae caelatae. Conclavibus autem, ubi ignis aut plura lumina sunt ponenda, pura⁴ fieri debent, ut ea⁵ facilius extergeantur; in aestivis et exhedris, ubi minime fumus est nec fuligo potest nocere, ibi caelatae sunt faciendae. Semper enim album opus propter superbiam candoris non modo ex propriis sed etiam alienis aedificiis concipit fumum.

5 Coronis explicatis parietes quam⁶ asperrime trullissentur, postea autem supra, trullissatione⁷ subarescente, deformentur deredectiones harenati, uti longitudines ad regulam et ad lineam, altitudines ad perpendicularum, anguli ad normam respondentes

¹ duos *G*: uos *H*, .II.OS *S*.

² tomice *G*: -cae *H*.

³ ex creto *Joc*: excepto *H*.

⁴ pura *H G*.

⁵ eo *Bondam*: ea *H*, neutrum generale = eae res.

⁶ quem *H*.

⁷ trullissatione *S*: -nē *G*, -nem *H*.

thickness, provided that not more than two feet separates the knots of the bundles. These then are to be fixed with cord to the ribs as already described, and wooden pins are to be driven through them. Everything else is to be done as already described. 3. When the arched surfaces are fixed and interwoven with the reeds, the under surface is to be rough cast; then sand is to be applied and afterwards finished with hair mortar or marble.

When the coved surfaces are finished, the cornices must be carried along the springing below them, and these must be made as light and slender as possible. For when they are large, they settle under their own weight and cannot keep their place. Gypsum should not be employed, but selected marble of uniform texture, lest the gypsum by setting too soon prevent the work from drying uniformly. Further, we must avoid in these arched ceilings the old arrangements, because, in them, the projecting surfaces of the cornices overhang dangerously with their heavy weight. 4. Now there are other and more elaborate forms of cornice. In apartments, however, where there is a fire and lamps, the cornices should be plain so that they may be the more easily dusted. They can be carved in summer rooms and exedrae where there is very little smoke and soot cannot do any damage. For plaster work, with its glittering whiteness, takes up the smoke that comes from other buildings as well as from the owner's.

5. When the cornices are finished, the walls are to be rough-cast as coarsely as possible, and when the rough-cast is nearly dry, the surface of sand must be shaped in such a way that the lengths are set out by the rule and square, the heights by the

exigantur; namque sic emendata tectoriorum¹ in picturis erit species. Subarescente iterum et tertio inducatur; ita cum fundatior erit ex harenato² directura, eo firmior erit ad vetustatem soliditas tectorii.

6 Cum ab harena praeter trullissationem non minus tribus coriis fuerit deformatum, tunc e marmore graneo³ dereductiones sunt subigendae, dum ita materies temperetur, uti, cum subigatur, non haereat ad rutrum, sed purum ferrum e mortario⁴ liberetur. Grandi inducto et inarescente alterum corium mediocre dirigatur; id cum subactum fuerit et bene fricatum, subtilius inducatur. Ita cum tribus coriis harenae et item marmoris solidati parietes fuerint, neque rimas neque aliud vitium in se recipere poterunt.

7 Sed et liaculorum subactionibus fundata soliditate marmorisque candore⁵ firmo levigata,⁶ coloribus cum politionibus inductis nitidos⁷ expriment splendores. Colores autem, udo⁸ tectorio cum diligenter sunt inducti, ideo non remittunt sed sunt perpetuo permanentes, quod calx, in fornacibus excocto liquore facta raritatibus et evanida, ieiunitate coacta corripit in se quae res forte contigerunt, mixtionibusque ex aliis potestatibus conlatis seminibus seu principis una solidescendo, in quibuscumque membris est formata

¹ tectoriorum *Joc*: tectorum *H*.

² harenato *G*: -ta *H S*.

³ graneo (*granio Fav.*) *Kr*: grandio *H*.

⁴ murtario *H*. ⁵ candore *ed*: -rē *G S*, -rem *H*.

⁶ levigata *Ro*: -tae *G*, -te *H S*. ⁷ nitidus *H*.

⁸ udo *Joc*: nudo *H*.

plummet, the corners by the set-square. For in this way the designs of the fresco-paintings will not be interfered with. A second and third coat is to be applied, as the one underneath dries. Thus when the solidity of the plaster is the more established from the application of the coats of sand, it is the more stable and enduring.

6. When in addition to the rough-cast, not less than three coats of sand have been laid, then coats of powdered marble are to be worked up, and the mortar is to be so mixed, that when it is worked up it does not adhere to the trowel, but the iron comes clean from the mortar. When a thick layer has been spread and is drying, a second thin coat is to be spread. And when this has been worked up and rubbed over, a still finer coat is to be applied. When the walls have been made solid with three coats of sand and also of marble, they will not be subject to cracks or any other fault.

7. After they are rendered solid by the use of the plasterer's tools and polished to the whiteness of marble, they will show a glittering splendour when the colours¹ are laid on with the last coat. When the colours are carefully laid upon the wet plaster, they do not fail but are permanently durable, because the lime has its moisture removed in the kilns, and becoming attenuated and porous, is compelled by its dryness to seize upon whatever happens to present itself. It gathers seeds or elements by mixture with other potencies,² and becoming solid

¹ The colours employed in the 'incrustation style' at Pompeii, are such as might be found in marble: black, white, reddish-violet, warm wine-red, dirty yellow, dark bluish-green, no blue. Baumeister, *Denkmäler*, 1376.

² *Potestates herbarum*, Verg. *A.* xii. 396.

cum fit arida, redigitur, uti sui generis proprias videatur¹ habere qualitates.

8 Itaque tectoria, quae recte sunt facta, neque vetustatibus fiunt horrida neque, cum extergentur, remittunt colores, nisi si parum diligenter et in arido fuerint inducti.² Cum ergo itaque in parietibus tectoria facta fuerint, uti supra scriptum est, et firmitatem et splendorem et ad vetustatem permanentem virtutem poterunt habere. Cum vero unum corium harenae et unum minuti marmoris erit inductum, tenuitas eius minus valendo faciliter rumpitur nec splendorem politionibus propter inbecillitatem crassitudinis proprium optinebit.

9 Quemadmodum enim speculum argenteum tenui lamella ductum incertas et³ sine viribus habet remissiores splendores, quod autem e solida temperatura fuerit factum, recipiens in se firmis viribus politionem fulgentes in aspectu certasque considerantibus imagines reddet, sic tectoria, quae ex tenui sunt ducta, non modo sunt rimosa, sed etiam celeriter evanescent, quae autem fundata harenationis et marmoris soliditate sunt crassitudine spissa, cum sunt politionibus⁴ crebris subacta, non modo sunt nitentia, sed etiam imagines expressas aspicientibus ex eo opere remittunt.

10 Graecorum vero tectores non solum his rationibus utendo faciunt opera firma, sed etiam mortario conlocato, calce et harena ibi confusa, decuria hominum inducta ligneis vectibus pisant materiam, et ita ad cisternam⁵ subacta tunc utuntur. Itaque veteribus parietibus nonnulli crustas excidentis pro

¹ videatur *Joc*: videtur *H*.

² inducti *Joc*: -ta *H*.

³ incertas et *GS*: incerta. sed *H*.

⁴ politionibus *H*. ⁵ cisternam *Gr*: certamen *H*.

with whatever parts it is formed, it dries together so that it seems to have the qualities proper to its kind.

8. Stucco, therefore, when it is well made, does not become rough in lapse of time, nor lose its colours when they are dusted, unless they have been laid on carelessly and on a dry surface. When, therefore, stucco has been executed on walls in accordance with these instructions, it will retain its firmness and brilliance and fine quality. But when only one coat of sand and one of sifted marble is applied, the thin stucco cannot resist damage and is easily broken, and it does not keep a finish of proper brilliance because of its inadequate thickness.

9. For just as a silvered mirror covered with a thin layer gives back confused and ineffective reflections, while one that is made with a solid layer takes by its firmness a good finish, and reflects images which shine to the view and are clear to the spectator, so stucco which is spread with thin mortar soon cracks and perishes, while that which is based upon solid sand and marble of a suitable thickness, and is worked up by repeated polishing, not only shines but reflects clear images¹ from the wall to the spectator.

10. The Greek² plasterers not only make their work firm by using these methods, but they make a mortar trough with lime and sand mixed, and a gang of men beat the mortar with wooden staves, and they use the mortar thus worked up in the pit. Therefore some cut out panels from old walls and

¹ The stucco serves in some places as a mirror.

² Greek materials and technique were taken over and developed by Roman craftsmen.

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abacis utuntur, ipsaque tectoria abacorum et speculorum divisionibus circa se prominentes habent expressiones.

- 11 Sin autem in craticis tectoria erunt facienda, quibus necesse est in arrectariis et transversariis rimas fieri, ideo quod, luto cum linuntur, necessario recipiunt umorem, cum autem arescent, extenuati in tectoriis faciunt rimas, id ut non fiat, haec erit ratio. Cum paries totus luto inquinatus fuerit, tunc in eo opere cannae clavis muscariis perpetuae figantur, deinde iterum luto inducto, si priores transversariis harundinibus¹ fixae sunt, secundae erectis figantur, et uti supra scriptum est, harenatum et marmor et omne tectorium inducatur. Ita cannarum duplex in parietibus harundinibus transversis fixa perpetuitas nec tegmina nec rimam ullam fieri patietur.

IV

- 1 QUIBUS rationibus siccis locis tectoria oporteat fieri, dixi; nunc, quemadmodum umidis locis politiones² expédiantur, ut permanere possint sine vitiis, exponam. Et primum conclavibus, quae plano pede fuerint, in imo pavimento alte circiter pedibus tribus pro harenato testa trullissetur³ et dirigatur, uti eae partes tectoriorum ab umore ne vitientur. Sin autem aliqui paries perpetuos habuerit umores, paululum ab eo recedatur et struatur alter tenuis

¹ harundibus *H.*

² politiones *H.*

³ trullissetur *H S.*

¹ *Pes* = ground; cf. 'footing,' Seneca, *Tranq. An.* X. 4.

BOOK VII. C. III.—C. IV.

use them like easel pictures. For the plaster work itself being divided into panels and mirrors, furnishes images which seem to stand out from it.

11. But if plastering is required on timber partitions, owing to their uprights and cross-pieces, cracks are bound to appear in it. For when they are coated with clay they must take up moisture; and when dry they shrink and cause cracks in the plaster. Hence the following precautions must be taken. When the whole wall has been smeared with clay, reeds are to be fixed right along with broad-headed nails. When a second layer of clay is put on, if the first coat has been set with horizontal reeds, the second must be set with the reeds vertical; according to the previous instructions, coats of sand and marble and indeed the complete coat of stucco may then be laid on. The double unbroken rows of reeds fixed crosswise on the walls will prevent any flaking off and the occurrence of cracks.

CHAPTER IV

ON STUCCO IN DAMP PLACES

1. I HAVE described how plastering is to be done in dry places: I will now explain how stucco is executed in damp places so as to avoid blemishes. And first as to rooms on the level ground.¹ To the height of about three feet from the pavement, rough-cast made of powdered earthenware instead of sand, is to be laid on, so that this part of the plaster may not suffer from damp. But if any wall shows continued damp, we must go a little behind it, and build another wall, thin and distant from the first,

distans ab eo, quantum res patietur, et inter duos parietes canalis ducatur inferior, quam libramentum conclavis fuerit, habens nares ad locum patentem. Item, cum in altitudinem perstrictus¹ fuerit, relinquantur spiramenta; si enim non per nares umor et in imo et in summo habuerit exitus, non minus in nova structura se dissipabit. His perfectis paries testa trullissetur et dirigatur et tunc tectorio poliatur.

- 2 Sin autem locus non patietur structuram fieri, canales fiant et nares exeant² ad locum patentem. Deinde tegulae bipedales ex una parte supra marginem canal³ inponantur, ex altera parte besalibus pilae substruantur, in quibus duarum tegularum anguli sedere possint, et ita a pariete eae distent,⁴ ut ne plus pateant palmum. Deinde insuper erectae hamatae⁵ tegulae ab imo ad summum ad parietem figantur, quarum interiores partes curiosius picentur, ut ab se respuant liquorem; item in imo et in summo supra camaram habeant spiramenta.⁶

- 3 Tum autem calce ex aqua liquida dealbentur, uti trullissationem testaceam⁷ non respuant; namque propter ieiunitatem quae est a fornacibus excocta non possunt recipere nec sustinere, nisi calx subiecta utrasque res inter se conglutinet et cogat coire.⁸ Trullissatione inducta pro harenato testa dirigatur, et cetera omnia, uti supra scripta sunt in tectorii⁹ rationibus, perficiantur.

- 4 Ipsi autem politionibus eorum ornatus proprios

¹ perstructus *S*: perstrictus *H G*.

² exeunt *H*. ³ canales *H*.

⁴ distent *G S*: distant *H S*.

⁵ hamatae *Gr*: amatae *H S*, ammate *G*.

⁶ spiramenta *Joc*: stramenta *H*.

⁷ testaceam *rec*: testae tam *H*.

⁸ cogat *G*: cogitat quaire *H*.

⁹ tectorii *S*: -rio *H*.

as far as the case admits. Between the two walls, a gutter must be laid lower than the level of the room, with outlets into the open. Further, when the wall is built to the top, ventilation holes are to be left. For unless the moisture has outlets, it will none the less diffuse itself over the new wall. When these precautions have been taken, let the wall be rough-cast with powdered pottery, brought to an even surface and finished with plaster.

2. But if the space is not enough for another wall, let gutters be made with outlets to the open. Then let two-foot tiles¹ be placed above the edge of the gutter on the one side; on the other side, piers² of eight-inch bricks are to be built up, to take the edges of two tiles, and let the piers be distant not more than one palm's length from the wall. Then let flanged³ tiles be fixed to the wall vertically from the bottom to the top. Their inner side is to be carefully covered with pitch so as to reject the moisture. Also let there be air-holes at the bottom, and at the top above the spring of the ceiling.

3. They are then to be whitened over with lime and water so that they do not reject the rough-cast of powdered brick; for from the dryness that comes in the kiln they can neither take nor keep this coating unless the lime that is applied, glues both together and causes their union. When the rough-cast is put on, broken pottery is to be used instead of sand and the remainder is to be finished as described above about plastering.

4. The craftsmen, again, in the stucco-work, must

¹ 18-inch tiles, *sesquipedales*, Book V. x. 2.

² Book V. x. 2.

³ Lit. 'hooked.'

debent habere ad decoris rationes, uti et ex locis aptas et generum discriminibus non alienas habeant dignitates. Tricliniis hibernis non est utilis compositione nec melographia¹ nec camerarum coronario opere subtilis ornatus, quod ea et ab ignis fumo et ab luminum crebris fuliginibus conrumpuntur. In his vero supra podia abaci ex atramento sunt subigendi et poliendi cuneis silaceis² seu miniaceis³ interpositis; explicatae camerae pure politae; etiam pavimentorum non erit displicens, si qui animadvertere voluerit Graecorum ad hibernaculorum usum. Minime sumptuosus est utilis apparatus.

5 Foditur enim intra⁴ libramentum triclini altitudo circiter pedum binum, et solo festucato inducitur aut rudus aut testaceum pavimentum ita fastigatum, ut in canali habeat⁵ nares. Deinde congestis et spisse calcatis carbonibus inducitur et sabulone et calce et favilla mixta materies crassitudine semipedali. Ad regulam et libellam summo libramento cote despumato redditur species nigri pavimenti. Ita convivii eorum et, quod poculis et pytismatis⁶ effundetur, simul cadit siccescitque, quique versantur ibi ministrantes, etsi nudis pedibus fuerint, non recipiunt fraces⁷ ab eius modi genere pavimenti.

¹ megalographia *Joc*: melographia *H*; cf. μελογραφειω *eccl.* vide *infra* v. 2.

² silaceis *Joc*: sileceis *H*.

³ se ominia|ceis *H*.

⁴ intra = infra ut saepe.

⁵ habeat *ed*: habeant *H*.

⁶ pytismatis *Salm*: sputismatis *H*.

⁷ fraces *Gr*: fragus *H*.

keep the designs in accordance with 'decor,'¹ that they may have a character fitted to their place and adjusted to the differences of style. In winter dining-rooms, painting of detail² is not useful in the composition, nor fine mouldings in the cornice under the vault, because they are damaged by the smoke from the fire and the frequent soot from the lamps.³ In these rooms, immediately above the dado, panels of black are to be worked up and finished with strips of yellow ochre or vermilion intervening. The arched ceilings have a plain finish. As to the pavements, it will not be unsatisfactory if we observe the arrangement of Greek winter apartments. A useful construction is not at all expensive. 5. For inside the levelled surface of the triclinium a depth of about two feet is dug. The ground is well rammed and a pavement of rubble or pounded brick is laid with a fall towards the gutter and its outlets. Then charcoal is collected and crushed by treading, and a mixture six inches thick of ashes, sand and lime is laid. The top surface is then rubbed with stone to rule and level, and has the appearance of a black pavement. At banquets, therefore, the wine which is thrown from the cups⁴ or spit out after tasting⁵ dries as it falls. And although the servants who are employed there are barefooted, their feet are not stained by the wine-lees on this kind of pavement.

² *m.* = 'anatomical drawing,' hence 'detail.' See v. 2. Plato uses μέλος and μέρος interchangeably, e.g. *Plat. Phileb.* 14E.

³ *Supra*, c. iii. 4.

⁴ The throwing of wine from the cup, *libatio*, was done in honour of a deity, or, like a toast, in honour of a person.

⁵ Wine was distinguished in tasting as rough, *asperum*, or smooth, *lene*, Ter. *Haut.* 458.

V

- 1 CETERIS conclavibus, id est vernis, autumnalibus, aestivis, etiam atriis et peristylis, constitutae sunt ab antiquis ex¹ certis rebus certae² rationes picturarum. Namque pictura imago fit eius, quod est seu potest esse, uti homines, aedificia, naves, reliquarumque rerum, e quibus finitis³ certisque corporibus figurata similitudine sumuntur exempla. Ex eo antiqui, qui initia expolitionibus instituerunt, imitati sunt primum crustarum marmorearum varietates et conlocationes, deinde coronarum, filicularum,⁴ cuneorum inter se varias distributiones.
- 2 Postea ingressi sunt, ut etiam aedificiorum figuras, columnarum et fastigiorum⁵ eminentes proiecturas⁶ imitarentur, patentibus autem locis, uti exhedris, propter amplitudines parietum scaenarum frontes tragico more aut comico seu satyrico designarent, ambulationibus vero propter spatia longitudinis varietatibus topiorum ornarent a certis⁷ locorum proprietatibus imagines exprimentes; pinguntur enim portus, promunturia, litora, flumina, fontes, euripi,⁸ fana, luci, montes, pecora, pastores. Nonnulli locis item signorum melographiam habentes deorum simulacra seu fabularum dispositas explica-

¹ ex certis *Joc* : & certis *H*.

² certę rationes *G* : ca&erationes *H*.

³ finitis *Mar* : finibus *H*.

⁴ filicularum *Gr* : siliculorum *H*.

⁵ fastidiorum *H S*.

⁶ proiecturas *Gr* : prolecturas *H S*.

⁷ certis *e*₁ : adcertis *H*. ⁸ eurypi *H G*.

¹ *Exemplum* = *Gk. paradeigma*, Herod. II. 86.

² Incrustation style : (a) plain, (b) florid.

CHAPTER V

ON WALL-PAINTING

1. IN other apartments for use in spring, autumn or summer, and also in atria and cloisters, the ancients used definite methods of painting definite objects. For by painting an image is made of what is, or of what may be; for example, men, buildings, ships, and other objects; of these definite and circumscribed bodies, imitations¹ are taken and fashioned in their likeness. Hence the ancients who first used polished stucco, began² by imitating the variety and arrangement of marble inlay; then the varied distribution of festoons, ferns, coloured strips.

2. Then they proceeded to imitate the contours of buildings, the outstanding projections of columns and gables;³ in open spaces, like exedrae, they designed scenery⁴ on a large scale in tragic, comic, or satyric style; in covered promenades, because of the length of the walls, they used for ornament the varieties of landscape gardening,⁵ finding subjects in the characteristics of particular places; for they paint harbours, headlands, shores, rivers, springs, straits, temples, groves, hills, cattle, shepherds. In places, some have also the anatomy of statues, the images of the gods, or the representations of legends;

¹ The latter was the transition to architectural style, Bm. 1377.

² Book V. vi. 9. Vitruvius suggests that the incrustation style corresponds to the tragic scenery; the architectural, to comic; the third, the landscape style, to satyric.

³ Stuart Jones suggests 'landscape' as the name of the third style, *Companion*, 402. This precisely corresponds to *topeodî species*, H. V. vi. 9.

tiones, non minus troianas pugnas seu Ulixis errationes per topia, ceteraque, quae sunt eorum similibus rationibus ab rerum natura procreata.

- 3 Sed haec, quae ex veris¹ rebus exempla sumebantur, nunc iniquis moribus inprobantur. <Nam pinguntur>² tectoriis monstra potius quam ex rebus finitis imagines certae: pro columnis enim struuntur calami striati, pro fastigiis appagineculi cum crispis foliis et volutis, item candelabra aedicularum sustinentia figuras, supra fastigia eorum surgentes ex radicibus cum volutis³ teneri plures habentes in se sine ratione sedentia sigilla, non minus coliculi dimidiata⁴ habentes sigilla alia humanis, alia bestiarum capitibus.

- 4 Haec autem nec sunt nec fieri possunt nec fuerunt. Ergo ita novi mores coegerunt, uti inertiae mali iudices convincerent artium virtutes: quemadmodum enim potest calamus vere sustinere tectum aut candelabrum ornamenta fastigii, seu coliculus⁵ tam tenuis et mollis sustinere sedens sigillum, aut de radicibus et coliculis ex parte flores dimidiataque sigilla procreari? At haec falsa videntes homines non reprehendunt sed delectantur, neque animadvertunt, si quid eorum fieri potest necne. Iudiciis autem infirmis obscuratae mentes non valent probare, quod potest esse cum auctoritate et ratione decoris. Neque enim picturae probari debent, quae non sunt similes veritati, nec, si factae sunt elegantes ab arte, ideo de his statim debet 'recte' iudicari, nisi

¹ veris *e*, v&eris *H*, veteris *S*, veteribus *G*.

² nam pinguntur *G*: om. *H S*.

³ voluteis *H*.

⁴ dimidiata *Joc*: dimidiati *H*.

⁵ culiculus *H S*.

further, the battles of Troy and the wanderings of Ulysses over the countryside with other subjects taken in like manner from Nature.

3. But these which were imitations based upon reality are now disdained by the improper taste¹ of the present. On the stucco are monsters rather than definite representations taken from definite things. Instead of columns there rise up stalks; instead of gables, striped panels with curled leaves and volutes. Candelabra uphold pictured shrines and above the summits of these, clusters of thin stalks rise from their roots in tendrils with little figures seated upon them at random. Again, slender stalks with heads of men and of animals attached to half the body.

4. Such things neither are, nor can be, nor have been. On these lines the new fashions compel bad judges to condemn good craftsmanship for dullness. For how can a reed actually sustain a roof, or a candelabrum the ornaments of a gable? or a soft and slender stalk, a seated statue? or how can flowers and half-statues rise alternately from roots and stalks? Yet when people view these falsehoods, they approve rather than condemn, failing to consider whether any of them can really occur or not. Minds darkened by imperfect standards of taste cannot discern the combination of impressiveness with a reasoned scheme of decoration. For pictures cannot be approved which do not resemble reality. Even if they have a fine and craftsmanlike finish, they are only to receive commendation if they

¹ Vitruvius follows the Stoic insistence on reality, as distinguished from the fantastic compositions which transformed the 'architectural' style under Alexandrian influences.

argumentationes certas rationes habuerint sine offensionibus explicatas.

- 5 Etenim etiam Trallibus cum Apaturius Alabandus eleganti manu finxisset scaenam in minusclo theatro, quod ecclesiasterion¹ apud eos vocitatur, in eaque fecisset columnas, signa, centauros sustinentes epistylia, tholorum² rotunda tecta, fastigiorum prominentes versuras, coronasque capitibus leoninis ornatas, quae omnia stillicidiorum e tectis habent rationem, praeterea supra ea nihilominus episcenium, in qua tholi, pronai, semifastigia omnisque tecti varius picturis fuerat ornatus, itaque cum aspectus eius scaenae propter asperitatem eblandiretur omnium visus et iam id opus probare fuissent parati, tum Licymnius³ mathematicus prodiit et ait
- 6 ' Alabandis satis acutos ad omnes res civiles haberi,⁴ sed propter non magnum vitium indecentiae insipientes eos esse iudicatos,⁵ quod in gymnasio⁶ eorum quae sunt statuæ omnes sunt causas⁷ agentes, foro discos tenentes aut currentes seu pila ludentes. Ita indecens inter locorum proprietates status signorum publice civitati⁸ vitium existimationis adiecit. Videamus item nunc, ne a picturis scaena efficiat et nos Alabandis⁹ aut Abderitas. Qui enim vestrum domos supra tegularum tecta potest habere aut columnas seu fastigiorum expolitionis?¹⁰ Haec enim supra contignationis ponuntur, non supra tegularum tecta. Si ergo, quae non possunt in

¹ ἐκκλησιαστήριον *Joc*: eglisinterion *H*.

² tholorum *Joc*: pholumorum *H S G*.

³ Licymnius *Sillig*: lichinus *H*.

⁴ haberi *G*: habere *H S*. ⁵ iudicatus *H S*.

⁶ gipnasio *H*.

⁷ causas *G*: causa *H S*.

⁸ civitati *Joc*: -tis *H*.

⁹ Alabandis *Kr*: alabandas *H*.

¹⁰ expolitionis *H*: expolicionis *S*.

exhibit their proper subject without transgressing the rules of art.

5. At Tralles,¹ Apaturius of Alabanda had invented scenery of fine technique for the tiny theatre which they call the Small Assembly. In this he showed columns, statues, or centaurs supporting the architraves, the orbed roofs of domes, the projecting angles of pediments, cornices having lions' heads which provided outlets for the rain from the roofs. Besides, the story above the scenery had domes, porticoes, half pediments, and every kind of roof, with varied pictorial ornament. When, therefore, the appearance of such a stage, by its high relief,² charmed the eyes of all, and they were already on the point of applauding it, Licymnius the mathematician came forward and said, that (6) 'the inhabitants were shrewd enough in politics, but they had the reputation of being stupid because of one not very great fault, inconsistency. In the gymnasium, the statues were all of politicians; in the public assembly, they were of quoit-throwers or runners or javelin-throwers. Thus the unsuitable disposition of the statues added a blemish to the city in public estimation. Let us see to it that our stage scenery with its pictures does not make us citizens of Alabanda or of Abdera!³ For who of you can have above your roof tiles, buildings with columns and elaborate gables? For the latter stand upon floors, not above the roof tiles. If therefore,

¹ VII. *pref.* 12.

² The effect of perspective is compared to repoussé work; cf. Verg. *A.* v. 267. *cymbia . . . aspera signis.*

³ Abdera, proverbially a city of fools; Alabanda, proverbial for its luxury, Strabo XIV. 661.

veritate rationem habere facti, in picturis probaverimus, accedimus et nos his civitatibus, quae propter haec vitia insipientes sunt iudicatae.'

7 Itaque Apaturius contra respondere non est ausus, sed sustulit scaenam et ad rationem veritatis commutatam postea correctam adprobavit.¹ Utinam dii immortales fecissent, uti Licymnius² revivisceret et corrigeret hanc amentiam tectoriorumque errantia instituta! Sed quare vincat veritatem ratio falsa, non erit alienum exponere. Quod enim antiqui insumentes laborem ad industriam probare contendebant artibus, id nunc coloribus et eorum alleganti³ specie consecuntur, et quam subtilitas artificis adiciebat operibus auctoritatem, nunc dominicus sumptus efficit, ne desideretur.

8 Quis enim antiquorum non uti medicamento minio parce videtur usus esse? At nunc passim plerumque toti parietes inducuntur. Accedit huc chrysocolla, ostrum, armenium. Haec vero cum inducuntur, etsi non ab arte sunt posita, fulgentes oculorum reddunt visus, et ideo quod pretiosa sunt, legibus excipiuntur, ut ab domino, non a redemptore repraesententur.

Quae commune facere⁴ potui, ut ab errore cedatur in opere tectorio, satis exposui; nunc de apparitionibus, ut succurrere potuerit, dicam, et primum, quoniam de calce initio est dictum, nunc de marmore ponam.

¹ adprobabit *H S.* ² uti licinius *H G*, utlicinius *S.*

³ alleganti *Gr*: aliganti *H.*

⁴ cum monefacere *H* = κοινωνεῖν *N.T.*

we approve in pictures what cannot justify itself in reality, we are added to those cities which, because of such faults, are esteemed slow-witted.'

7. So Apaturius had not the courage to reply, and removed the scenery; and when this was altered to resemble reality, he obtained sanction for his correction. O that heaven would raise Licymnius to life, and amend this madness, and the roving fashions of the fresco-painters! Now it is not foreign to our purpose to explain why a false method overcomes the truth. The aims which the ancients sought to realise by their painstaking¹ craftsmanship, the present attains by coloured materials and their enticing appearance. The dignity which buildings used to gain by the subtle skill of the craftsman, is not even missed owing to the lavish expenditure of the client.

8. For who of the ancients is not found to use minium as sparingly as the apothecary? But at the present day whole walls are covered with it everywhere. To it is added malachite, purple, Armenian ultramarine. And when these are applied, apart from any question of skill, they affect the vision of the eyes with brilliance. Because of their costliness they are excluded in the specification, so that they are charged to the client and not to the contractor.

I have sufficiently set forth the advice I could give for avoiding mistakes in the plaster work. I will now deal with the necessary supplies, as it may occur to me; and first—since lime has been mentioned to begin with—I will now describe marble.

¹ *ad industriam* = *de industria*.

VI

1 MARMOR non eodem genere omnibus regionibus procreatur, sed quibusdam locis glæbae ut salis micas perlucas habentes nascuntur, quæ contusæ et molitæ præstant operibus utilitatem. Quibus autem locis eae copiae non sunt, caementa marmorea, sive assulae¹ dicuntur, quæ marmorarii ex operibus deiciunt, contunduntur² et moluntur, subcretum in operibus utuntur. Aliis locis, ut inter Magnesiæ et Ephesi fines, sunt loca, unde foditur <glæba> parata, quam nec molere nec cernere opus est, sed sic est subtilis,³ quemadmodum si qua est manu contusa et subcreta.

Colores vero alii⁴ sunt, qui per se certis locis procreantur⁵ et inde fodiuntur, nonnulli ex aliis rebus tractationibus aut mixtionum⁶ temperaturis compositi perficiuntur, uti præsent in eandem operibus utilitatem.

¹ assilæ H.

² contunduntur et molliuntur et is qui ex his etc. viii. 2.—*expolitus et aridus* ix. 3 H. *verum ordinem restituit Lorentzen.*

³ subtilis *ed. Fl*: subtilius H.

⁴ aliis H.

⁵ procreantur H.

⁶ mixtionum Nohl: mixtionibus H.

¹ At this point the next leaf of the archetype begins: *est subcretum*, and goes on to *interarescant*, *infra* viii. 2. The next leaf but one begins *et is qui ex his*, viii. 2, and goes on to *expolitus et aridus*, ix. 3. These two leaves were interchanged so that the second followed upon *contunduntur et molliuntur* in H and the first leaf followed upon the end of the second after *expolitus et aridus*. In the Escorial MS. *e*, there is the marginal note at *molliuntur* (sic): *Inversa sunt hæc omnia eadem serie*

BOOK VII. c. vi.

CHAPTER VI

ON THE USE OF MARBLE

1. MARBLE is not found of the same kind in all regions. In some places, blocks occur with shining flakes, as of salt. And these being crushed and ground are of use. But where there are no such supplies, marble-rubble, or splinters as they are called, which the marble workers throw down from their benches, are crushed and ground.¹ This material when sifted the plasterers use in their work. Elsewhere, for example between the boundaries of Magnesia and Ephesus, there are places where it is dug up ready for use, and need not be ground nor sifted.² It is as fine as if it had been crushed by hand and sifted.

There are other coloured materials which occur in a natural state in certain places, and are dug up from mines. Yet others are composed of different substances and are treated and blended so as to serve the same³ purposes in buildings.

quae in Blandiniano c habetur. (c = codice.) The end of the second leaf is marked, but *est* is attached to *aridus*. *subcretum* is an accusative after *utuntur*. Jocundus, who first printed the text in the proper order, rewrote the Latin of the chapter on marble after *deiciunt*, down to *colores vero*, etc., where he takes up the text again. His interpolation appeared in the Tauchnitz Latin text and was followed by Gwilt; it was detected by Schneider, who, however, thought that Jocundus took it from a MS.

¹ When a compound verb occurs, it is repeated in the simple form, e.g. *exposui* and *ponam*, VII. v. 8; here *subcretum*, *cernere*.

² *In eandem*: use of preposition before direct object, cf. Cyprian *ad Donatum* 1, *in arbores et in vites videmus*.

VII

- 1 PRIMUM autem exponemus, quae per se nascentia fodiuntur, uti sil,¹ quod graece *ochra*² dicitur. Haec vero multis locis, ut etiam in Italia, invenitur; sed quae fuerat optima, attica, ideo nunc non habetur, quod Athenis argentifodinae cum habuerunt familias, tunc specus sub terra fodiebantur ad argentum inveniendum. Cum ibi vena forte inveniretur, nihilominus uti argentum persequerentur³; itaque antiqui egregia copia silis ad politionem operum sunt usi.
- 2 Item rubricae copiosae multis locis eximuntur, sed optimae paucis, uti Ponto Sinope, et Aegypto, in Hispania Balearibus, non minus etiam Lemno, cuius insulae vectigalia Atheniensibus senatus populusque
- 3 Romanus concessit fruenda. Paraetonium vero ex ipsis locis, unde foditur, habet nomen. Eadem ratione melinum, quod eius metallum⁴ insula cycladi
- 4 Melo dicitur esse. Creta viridis item pluribus locis nascitur, sed optima Zmyrnae; hanc autem Graeci *Theodoteion*⁵ vocant, quod Theodotus nomine fuerat, cuius in fundo id genus cretae primum est
- 5 inventum. Auripigmentum, quod *arsenicon* graece dicitur, foditur Ponto. Sandaraca⁶ item pluribus locis, sed optima Ponto proxime flumen Hypanim habet metallum.

¹ sil Schn : si H.² ochras H.³ persequerentur H.⁴ metallum Ro : metalli insulae H.⁵ theodoteū H.⁶ pontos andarea H.

¹ "Yellow and scarlet appeal to the undamaged eye."—William Morris, *Life by Mackail*, I. 106.

² The ochres, yellow and red, are earths coloured by iron oxide.

³ At Laurium near Sunium.

⁴ About 167 B.C.

⁵ Calcium carbonate.

BOOK VII. c. VII.

CHAPTER VII

ON NATURAL COLOURS

1. FIRST we will describe the colours¹ which are dug up in their natural state, such as the yellow¹ material which the Greeks call ochre.² This is found in many places, as also in Italy. What used to be the best, the Attic, is not available now, for the following reason. When the silver mines at Athens³ were worked, shafts were dug underground to find silver; but when a vein of ochre happened to be found, they worked it no less than silver. Hence the ancients used a large amount of yellow in their frescoes.

2. Abundant *red* ochre, also, is extracted in many places, but the best is only found in a few, such as Sinope in Pontus, and in Egypt, in Spain in the Balearic Isles, and also in Lemnos, where the Roman government⁴ handed over the revenues to the Athenians. 3. Paraetionium white⁵ has its name from the place⁶ where it is mined. In the same way Melian white has its name because a mine is said to occur in Melos, an island of the Cyclades. 4. Green chalk is found in many places, but the best is from Smyrna, which the Greeks call *Theodoteion*, because Theodotus was the name of the man on whose land it was first found. 5. Orpiment,⁷ which the Greeks call arsenic is mined in Pontus. Red arsenic⁸ also, in many places, but the best is mined in Pontus close to the river Hypanis.⁹

¹ Paraetionium on the coast of Tripoli.

⁷ Arsenious sulphide.

⁸ Arsenic disulphide.

⁹ River Boug, in S. Russia.

VIII

- 1 INGREDIAR nunc minii rationes explicare. Id autem agris Ephesiorum Cilbianis¹ primum esse memoratur inventum. Cuius et res et ratio satis magnas habet admirationes. Foditur enim glæba quæ dicitur, antequam tractationibus ad minium perveniant, vena uti ferrum,² magis subrufo colore, habens circa se rubrum pulverem. Cum id foditur, ex plagis ferramentorum crebras emittit laerimas argenti vivi, quæ a fossoribus statim colliguntur.
- 2 Hæ glæbæ, cum collectæ sunt in officinam, propter umoris plenitatem coiciuntur in fornacem, ut interarescant,³ et is qui ex his ab ignis vapore fumus suscitatur, cum resedit in solum furni, invenitur esse argentum vivum. Exemptis glæbis guttæ eae, quæ residebunt,⁴ propter brevitates non possunt colligi, sed in vas aquæ⁵ converruntur et ibi inter se congruunt et una confunduntur. Id autem cum sint quattuor sextariorum mensuræ, cum expenduntur, invenientur esse pondo centum.
- 3 Cum in aliquo⁶ vase est confusum,⁷ si supra id lapide⁸ centenarium pondus inponatur, natat in summo neque eum liquorem potest onere suo premere nec elidere nec dissipare. Centenario sublato si ibi auri scripulum ponatur, non nabit,

¹ Cilbianis *Phil*: cliuvianis *H*.

² ferrum *Ro*: ferro *H*.

³ interarescant fuerit ceram punicam *etc.* (ix. 3) *H*.

⁴ resedebunt *H*.

⁵ in vasa quæ *H*.

⁶ alico *H*.

⁷ confusum *ed*: -sus *H*.

⁸ lapidē *H*.

CHAPTER VIII

ON VERMILION AND QUICKSILVER

1. I WILL now go on to describe the treatment of minium¹ or vermilion. It is said to have been discovered in the Cilbian Fields of Ephesus.² The material and its treatment is sufficiently wonderful. For what is called the ore is first extracted. Then, using certain processes, they find minium. In the veins the ore is like iron, of a more caroty colour, with a red dust round it. When it is mined, and is worked with iron tools, it exudes many drops of quicksilver, and these are at once collected by the miners.

2. When the ore has been collected in the workshop, because of the large amount of moisture, it is put in the furnace to dry. The vapour which is produced by the heat of the fire, when it condenses on the floor of the oven, is found to be quicksilver. When the ore is taken away, the drops which settle because of their minuteness cannot be gathered up, but are swept into a vessel of water: there they gather together and unite. Four sextarii of quicksilver when they are weighed come to 100 lbs.³

3. When quicksilver is poured into a vessel, and a stone weight of 100 lbs. is placed upon it, the stone floats upon the surface. For it is unable by its weight to press the liquid down and so squeeze it out and separate it. If the stone is taken away and a scruple⁴ of gold is placed upon the quicksilver, it

¹ Sulphide of mercury.

² A fuller account is given by Pliny, *N.H.* XXXIII. 113.

³ *Sextarius* = .96 pint; *libra* = .7 lb. ⁴ 17.5 gr.

sed ad imum per se deprimetur. Ita non amplitudine ponderis sed genere singularum rerum gravitatem esse non est negandum.

- 4 Id autem multis rebus est ad usum expeditum. Neque enim argentum neque aes sine eo potest recte inaurari. Cumque in vestem intextum est aurum eaque vestis contrita¹ propter vetustatem usum non habeat honestum, panni in fictilibus vasis inpositi supra ignem conburuntur. Is cinis coicitur² in aquam, et additur eo argentum vivum. Id autem omnis micas auri corripit in se et cogit secum coire. Aqua diffusa cum id in pannum infunditur et ibi manibus premitur, argentum per panni raritates propter liquorem extra labitur, aurum compressione coactum intra purum invenitur.

IX

- 1 REVERTAR nunc ad minii temperaturam. Ipsae enim glabrae, cum sunt aridae, contunduntur pilis ferreis, et lotionibus et cocturis crebris relictis stercoribus efficiuntur, ut adveniant, colores. Cum ergo emissae³ sint ex minio⁴ per argenti vivi relictionem quas in se naturales habuerat virtutes, 2 efficitur tenera natura et viribus inbecillis. Itaque cum est in expolitionibus conclavium tectis inductum, permanet sine vitiis suo colore; apertis vero, id est peristyliis aut exhedris aut ceteris eiusdem modi locis,⁵ quo sol et luna possit splendores et radios

¹ constricta H. ² coigitur H.

³ emissae sint (Schn) Ro: emissa esset H.

⁴ minio Schn: minii H.

⁵ post locis H paginam aversam folii 103, fortasse propter membranae tenuitatem, vacuum exhibet.

will not swim, but is pressed down to the bottom, of itself. We cannot deny, therefore, that the gravity of bodies depends on their species¹ and not on their volume.

4. Quicksilver is adapted for many uses. Without it neither silver nor brass can be properly gilt. When gold is embroidered in cloth, and the garment, being worn out by age, is no longer fit for use, the cloth is put in earthenware vessels and burnt over the fire. The ashes are thrown into water, and quicksilver is added. This collects all the particles of gold and combines with them. The water is then poured away and the remainder is placed on a cloth, and is pressed by hand. Under this pressure the quicksilver being liquid passes through the pores of the cloth, and the pure gold is retained within.

CHAPTER IX

ON THE PREPARATION OF MINIMUM

1. I WILL now return to the preparation of vermilion. When the ore is dry, it is bruised with iron rammers, and by frequent washing and heating, the waste is removed and the colour is produced. When, therefore, the quicksilver has thus been removed, minimum loses its natural virtues, and becomes soft and friable.² 2. And so when it is used in the finishing of enclosed apartments, it remains of its own colour without defects; but in open places like peristyles and exedrae and so forth, where the sun and moon can send their brightness and their rays,

¹ Principle of specific gravity stated.

² Neuburger, 193.

inmittere, cum ab his locus tangitur, vitiatur et amissa virtute coloris denigratur. Itaque cum et alii multi tum etiam Faberius scriba, cum in Aventino¹ voluisset habere domum eleganter expolitam, peristyllis parietes omnes induxit minio, qui post dies xxx facti sunt invenusto varioque colore. Itaque primo locavit inducendos alios colores.

- 3 At² si qui subtilior fuerit et voluerit expolitionem miniaciam suum colorem retinere, cum paries expolitus et aridus est,³ ceram punicam⁴ igni liquefactam paulo oleo temperatam saeta inducat; deinde postea carbonibus in ferreo vase compositis eam ceram a primo cum pariete calfaciundo sudare cogat fiatque, ut peraequetur; deinde tunc candela linteisque⁵ puris⁶ subigat, uti signa marmorea nuda⁴ curantur (haec autem *ganosis*⁷ graece dicitur): ita obstans cerae punicae⁸ lorica non patitur nec lunae splendorem nec solis radios lambendo⁹ eripere his politionibus colorem. Quae autem in Ephesiorum metallis fuerunt officinae, nunc traiectae sunt ideo Romam, quod id genus venae postea est inventum Hispaniae regionibus, quibus metallis glaebae portantur et per publicanos Romae curantur. Eae autem officinae sunt inter aedem Florae et Quirini.
- 5 Vitiatur minium¹⁰ admixta calce. Itaque si qui

¹ *aventino rec*: *adventino H.* ² *at EG*: *ad H S.*

³ *et aridus est subcretum etc. (supra c. vi. 1).*

⁴ *punicam e, Sulp*: *pumicam H.*

⁵ *linteis (Plin. N.H. XXXIII. 122)*: *cunctis H.*

⁶ *puris ed*: *pluris H.*

⁷ *γάνωσις Welcker*: *gnosis H.*

⁸ *pumicae H S.*

⁹ *lambendo ed*: *labendo H.*

¹⁰ *minimum H.*

¹ After being in Caesar's service, he forged documents for Antony. *Cic. Att. XIV. 18. 1.*

the part so affected is damaged and becomes black, when the colour loses its strength. Among the many instances of this is the case of the public official Faberius.¹ He wished to have his palace on the Aventine² elegantly finished, and had all the walls of the peristyle covered with vermilion. In a month the walls turned to an unpleasant and uneven colour; and so he was the first to let a contract for laying on other colours.

3. But if anyone proceeds in a less crude fashion, and wishes a vermilion surface to keep its colour after the finishing of the wall is dry, let him apply with a strong brush Punic wax melted in the fire and mixed with a little oil. Then putting charcoal in an iron vessel, and heating the wall with it, let the wax first be brought to melt, and let it be smoothed over, then let it be worked over with waxed cord and clean linen cloths, in the same way as naked marble statues; this process is called *ganōsis* in Greek. 4. Thus a protective coat of Punic wax does not allow the brilliance of the moon or the rays of the sun to remove the colour from these finished surfaces by playing on them. The workshops which were in the Ephesian mines are now removed to Rome, because this kind of vein has been discovered in parts of Spain. The ore from the Spanish mines is conveyed to Rome and dealt with by the farmers-general. The workshops³ are between the temples of Flora and Quirinus.⁴

5. Minium is adulterated by the admixture of

¹ This plebeian quarter became fashionable under the empire.

² On the Quirinal. Platner, 371.

⁴ Book III. ii. 7.

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velit experiri id sine vitio esse, sic erit faciendum. Ferrea lamna sumatur, eo minium inponatur, ad ignem conlocetur, donec lamna candescat. Cum e candore color mutatus fuerit eritque ater, tollatur lamna ab igni, et sic refrigeratum restituatur in pristinum colorem; sine vitio esse probabit; sin autem permanserit nigro colore, significabit se esse vitiatum.

- 6 Quae succurrere potuerunt mihi de minio, dixi. Chrysocolla adportatur a Macedonia; foditur autem ex is locis, qui sunt proximi aerariis metallis. Armenium¹ et indicum nominibus² ipsis indicatur, quibus in locis procreatur.

X

- 1 INGREDIAR nunc ad ea, quae ex aliis generibus tractationum temperaturis commutata recipiunt colorum proprietates. Et primum exponam de atramento, cuius usus in operibus magnas habet necessitates, ut sint notae, quemadmodum praeparentur certis rationibus artificiorum, ad id temperaturae.
- 2 Namque aedificatur locus uti laconicum et expolitur marmore subtiliter et levigatur. Ante id fit fornacula habens in laconicum nares, et eius praefurnium magna diligentia conprimitur, ne³ flamma extra dissipetur. In fornace resina conlocatur.⁴ Hanc autem ignis potestas urendo cogit

¹ armenium *Schn*: minium *H*.

² nominibus *EG*: inomnibus *H S*.

³ nec *H et a. ras. S*.

⁴ collocetur *H S*.

lime. If anyone wishes to test its purity, the method is as follows. Take an iron plate, put the minium on it and set it on the fire until the plate is red-hot. When the colour is changed by the heat and is black, take the plate from the fire, and let the minium, on cooling, regain its former colour: its purity will be demonstrated. But if it remains black, it shows adulteration.

6. I have said what seemed of practical use about minium. Malachite is imported from Macedonia; it is mined in places which adjoin the copper mines. Ultramarine (armenium¹) and indigo (indicum²) show by their names the places where they are found.

CHAPTER X

ON BLACK

1. I WILL now proceed to those materials which, by special processes, are changed substantially, and acquire the properties of colour. And first I will deal with black. The use of this in buildings is often necessary, so that we must know how the tempering of materials for the purpose is carried out by special craftsmanship.

2. A vaulted apartment is built like a sweating chamber,³ and is covered carefully with a marble facing and smoothed down. In front of it a small furnace is built with outlets into the chamber, and the mouth of the furnace is carefully enclosed so that the flame does not escape. Resin is placed in the furnace. Now the fiery potency burns it and compels

¹ Probably azurite; perhaps powdered lapis lazuli.

² Indian ink. ³ Book V. x. 5.

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emittere per nares intra laconicum fuliginem, quae circa parietem et camerae curvaturam adhaerescit. Inde collecta partim componitur ex gummi subacta¹ ad usum atramenti librarii, reliquum tectores glutinum³ admiscentes in parietibus utuntur. Si autem hae copiae non fuerint paratae, ita necessitatibus erit administrandum, ne expectatione morae res retineatur. Sarmenta aut taedae schidiae comburantur; cum erunt carbonēs, extinguantur, deinde in mortario cum glutino² terantur; ita erit atramentum⁴ tectoribus non invenustum. Non minus si faex vini arefacta et cocta in fornace fuerit et ea contrita cum glutino in opere inducetur, super quam³ atramenti suavitatis efficiet colorem; et quo magis ex meliore vino parabitur, non modo atramenti, sed etiam indici colorem dabit imitari.

XI

1 CAERULI temperationes Alexandriae primum sunt inventae, postea item Vestorius⁴ Puteolis instituit faciundum. Ratio autem eius, e quibus est inventa, satis habet admirationis. Harena enim cum nitri flore conteritur adeo subtiliter, ut efficiatur quemadmodum farina; et aes cyprum⁵ limis crassis uti scobis facta⁶ mixta conspargitur, ut conglomeretur; deinde pilae manibus versando efficiuntur et ita

¹ subacta *Schn*: subacto *x*.

² glutino *H*.

³ super quam *Ro*: superque *H*.

⁴ Vestorius *e*₂: Nestorius *e*₂ *schol*, *Sulp*.

⁵ cyprum *H*: cyprium *e*₂ *Sulp*. *Plin. N.H. XXXIV. 116*.

⁶ facta *Kr*: factam *H*.

it to emit soot through the outlets into the chamber. The soot clings round the walls and vaulting of the chamber. It is then collected and in part compounded with gum and worked up for the use of writing ink; the rest is mixed with size and used by fresco-painters for colouring walls. 3. But if this cannot be obtained, we must satisfy our requirements without holding back the works by the delay involved. Brushwood or pine-chips must be burnt, and when they are charred they are to be pounded in a mortar with size. Thus the fresco-painters will have a not unpleasant black colour. 4. Again, a black colour even more pleasant than this is produced if the dregs of wine are dried and burnt in a furnace, and applied to the walls after being ground with size. The use of the finer wines will allow us to imitate not only black but indigo.

CHAPTER XI

ON BLUE AND YELLOW

1. THE processes for making blue were first discovered at Alexandria; afterwards also Vestorius founded a factory at Puteoli.¹ His method and his ingredients are sufficiently noteworthy. Sand is ground with flowers of soda to such fineness that it becomes like flour. Cyprian copper is sprinkled from rough files like fine dust so that it combines with the mixture. Then, it is rolled by hand into

¹ Vestorius, a banker of Puteoli, was the friend of Cicero and Atticus. He advised Cicero about building, *Att.* XIV. 9. 1. He was not interested in philosophy but a sound accountant, *Att.* XIV. 12. 3.

conligantur, ut inarescant; aridae componuntur in urceo fictili, urcei in fornace: ita ¹ aes et ea harena ab ignis vehementia confervescendo cum coaruerint, inter se dando et accipiendo sudores a proprietatibus discedunt suisque rebus per ignis vehementiam ² confectis ² caeruleo rediguntur colore. Usta vero, quae satis habet utilitatis in operibus tectoriis, sic temperatur. Glaeba silis ³ boni coquitur, ⁴ ut sit in igni candens; ea autem aceto extinguitur et efficitur purpureo colore.

XII

- 1 De cerussa aerugineque, quam nostri aerucam vocitant, non est alienum, quemadmodum comparetur, dicere. Rhodo enim doleis sarmenta conlocantes aceto suffuso supra sarmenta conlocant plumbeas massas, deinde ea operculis obturant, ne spiramentum obturatum emittatur. Post certum tempus aperientes inveniunt e massis plumbeis cerussam. Eadem ratione lamellas aereas conlocantes ² efficiunt aeruginem, quae aeruca appellatur. Cerussa vero, cum in fornace coquitur, mutato colore ad ignem incendi efficitur sandaraca—id autem incendio facto ex casu didicerunt homines—et ea multo meliorem usum praestat, quam quae de metallis per se nata foditur.

¹ ita *Schn*: sita ut *H*.

² silis *rec*: silix *H*.

² confectis *Rode*: -ti *H*.

⁴ quoquitur *H*.

¹ Artificial cinnabar discovered by Callias of Athens 315 B.C. *Plin. N.H. XXXIII. 113.*

² Lead acetate.

balls and they are put together to dry. When dry they are collected in an earthenware jar, and the jars are put in a furnace. In this way the copper and the sand burning together owing to the vehemence of the fire dry together, and, interchanging their vapours, lose their properties; and their own character being overcome by the vehemence of the fire, they acquire a blue colour. 2. Burnt 'cinnabar,'¹ which is very useful in plastering, is mixed as follows. Ore of good yellow ochre is roasted to a bright heat. It is quenched with vinegar and becomes of a purple colour.

CHAPTER XII

ON WHITE LEAD, VERDIGRIS, RED LEAD

1. It belongs to our subject to deal with the production of white lead and verdigris which our people call *aeruca*. At Rhodes they place a layer of chips in a large vessel, and pouring vinegar over them, they then put lumps of lead on the top. The vessel is covered with a lid lest the vapour which is enclosed should escape. It is opened after a certain time and the lead is found to be changed into *cerussa*.² In the same way, by using plates of copper they obtain verdigris or *aeruca*.³ 2. When white lead is roasted in a furnace, under the heat of the fire it changes its colour and becomes red lead or *sandaraca*.⁴ This fact was accidentally discovered in a conflagration. A much better result is obtained in this way than from the natural substance which is procured from the mines.

³ Basic copper acetate; mixed with wine, the green of MSS.

⁴ Lead oxide.

XIII

- 1 INCIPIAM nunc de ostro dicere, quod et carissimam et excellentissimam habet praeter hos colores aspectus suavitatem. Id autem excipitur e conchylio marino, e quo purpura¹ efficitur, cuius non minores sunt quam ceterarum <rerum>² naturae considerationibus admirationes, quod habet non in omnibus locis, quibus nascitur, unius generis colorem, sed
 2 solis cursu naturaliter temperatur. Itaque quod legitur Ponto et Gallia, quod hae regiones sunt proximae ad septentrionem, est atrum; progredientibus inter septentrionem et occidentem invenitur lividum; quod autem legitur ad aequinoctialem orientem et occidentem, invenitur violacio colore; quod vero meridianis regionibus excipitur, rubra procreatur potestate, et ideo hoc Rhodo etiam insula creatur ceterisque eiusmodi regionibus, quae prox-
 3 imae sunt solis cursui. Ea conchylia, cum sunt lecta, ferramentis circa scinduntur, e quibus plagis purpurea³ sanies, uti lacrima profluens, excussa in mortariis terendo comparatur. Et quod ex concharum marinarum testis eximitur, ideo ostrum est vocitatum. Id autem propter salsuginem cito fit siticulosum, nisi mel habeat circa fustum.

XIV

- 1 FIUNT etiam purpurei colores infecta creta rubiae⁴ radice et hysgino,⁵ non minus et ex floribus alii

¹ purpura *H S.*² *add. Joc.*³ purporea *H S.*⁴ rubiae *Joc* : rubra *H.*⁵ et hysgino *Joc* (*Plin. N.H. XXXV. 45*): et excygno *H.*¹ *Gk. ostreon = oyster.*

CHAPTER XIII

ON PURPLE

1. WE now turn to purple, which of all is most prized and has a most delightful colour excellent above all these. It is obtained from sea shells which yield the purple dye, and inspires in students of nature as much wonder as any other material. For it does not yield the same colour everywhere, but is modified naturally by the course of the sun. 2. What is collected in Pontus and Gaul is black because these regions are nearest to the north. As we proceed between the north and west it becomes a leaden blue. What is gathered in the equinoctial regions, east and west, is of a violet colour. But in the southern regions it has a red character; for example, in Rhodes and other similar regions which are nearest the sun's course. 3. When the shells have been collected, they are broken up with iron tools. Owing to these beatings a purple ooze like a liquid teardrop is collected by bruising in a mortar. And because it is gathered from the fragments of sea shells it is called *ostrum*.¹ On account of its saltness it soon dries unless it is mixed with honey.²

CHAPTER XIV

ON ARTIFICIAL COLOURS

1. PURPLE colours are also made by dyeing chalk with madder and hyssinum.³ Other colours also

¹ It is replaced in modern times by indigo derivatives.

² Dye made from a parasite of *quercus coccifera*, a small oak-bush found in Spain and N. Africa.

colores. Itaque tectores, cum volunt sil atticum ¹ imitari, violam aridam coicientes in vas cum aqua,² confervefaciunt ad ignem, deinde, cum est temperatum, coiciunt <in>³ linteum, et inde manibus exprimentes recipiunt in mortarium aquam ex violis coloratam, et eo cretam infundentes et eam terentes efficiunt silis attici colorem.

2 Eadem ratione vaccinium temperantes et lac-tem miscentes purpuram faciunt elegantem. Item qui non possunt chrysocolla propter caritatem uti, herba, quae luteum appellatur, caeruleum inficiunt, et utuntur viridissimum colorem; haec autem infectiva appellatur. Item propter inopiam coloris indici cretam selinusiam⁴ aut anulariam vitro,⁵ quod Graeci *isatin*⁶ appellant, inficientes imitationem faciunt indici coloris.

3 Quibus rationibus et rebus ad dispositionem firmitatis quibusque decoras oporteat fieri picturas, item quas habeant omnes colores in se potestates, ut mihi succurrere potuit, in hoc libro perscripsi. Itaque omnes aedificationum perfectiones, quam habere debeant opportunitatem ratiocinationis, septem voluminibus sunt finitae; insequenti autem de aqua, si quibus locis non fuerit, quemadmodum inveniatur et qua ratione ducatur quibusque rebus, si erit salubris et idonea, probetur, explicabo.

¹ sil acticum *H.*

² vas cum aqua *E G*: vas cum quā *H.* ³ *add. ed.*

⁴ selinusiam *Joc* (*Plin. N.H. XXXV. 46*): Sinysiam *H.*

⁵ vitro *Schn*: vitroque *H.*

⁶ *isatin* *Turnebus*: insallim *H.*

are obtained from flowers. When the stucco painters wish to imitate Attic ochre, they put dried yellow violets into a vessel with water and boil them. Then, when it is ready, it is poured on a cloth and squeezed by hand. They receive in a mortar the water coloured by the violets, and pouring chalk into it and rubbing it, they obtain the colour of Attic ochre.

2. In the same way they prepare whortleberries and mix them with milk, thus making a fine purple. Malachite is dear, and those who cannot afford it steep blue dye with the herb which is called weld¹ and obtain a brilliant green. This is called dyer's green. Also, because of the scarcity of indigo they make a dye of chalk from Selinus, or from broken beads, along with woad (which the Greeks call *isatis*), and obtain a substitute for indigo.

3. I have described in this book what suggested itself as of practical use, about the methods and materials required for stability, and how painting is employed in decoration, and, further, about the properties of colours. Thus in seven books I have defined the right methods of building and the due adjustment of the design. In the following book, which is about water, I will explain how it may be found where it is lacking, how it may be supplied and by what tests we may determine its wholesomeness and suitability for its purpose.

¹ A kind of mignonette yielding a yellow dye.

BOOK VIII

LIBER OCTAVUS

1 DE septem sapientibus Thales Milesius omnium rerum principium aquam est professus, Heraclitus ignem, Magorum sacerdotes aquam et ignem, Euripides, auditor Anaxagorae, quem philosophum Athenienses scaenicum appellaverunt, aera et terram, eamque e caelestium imbrium conceptionibus in-seminatam fetus gentium et omnium animalium in mundo procreavisse, et quae ex ea essent prognata, cum dissolverentur temporum necessitate¹ coacta in eandem² redire, quaeque de aere nascerentur,³ item in caeli regiones reverti neque interitiones recipere et dissolutione mutata in eam recidere, in qua ante fuerant,⁴ proprietatem. Pythagoras vero, Empedocles, Epicharmos alique physici et philosophi haec principia esse quattuor proposuerunt: aerem, ignem, terram, aquam, eorumque inter se cohaerentiam⁵ naturali figuratione e generum discriminibus efficere qualitates.

¹ necessitate *S*: -tē *H G*.

² eandem *G*: eadem *H S*.

³ de aere nascentur *G*, de aere nascentur *H*, de hac renascentur *S*.

⁴ fuerant *G*: fuerat *H*.

⁵ cohaerentiam *Gal*: -tia *H*.

¹ In the preface to Book VII, the pre-Socratic philosophers are distinguished as '*physici*'.

² The names are variously given, e.g. Plato, *Protag.* 343A.

BOOK VIII

PREFACE

1. THALES¹ of Miletus, one of the Seven Wise Men,² affirmed that the principle of all things is water; Heraclitus, fire; the priests of the Magi,³ water and fire; Euripides,⁴ the pupil of Anaxagoras, whom the Athenians named the philosopher on the stage, air and earth.⁵ 'The earth,' he said, 'impregnated by the seed contained in the rain from the sky, gives birth to mankind and all creatures living in the world; and whatever is born of earth, when it is dissolved by the necessary compulsion of time, returns to the same earth. What is born of the air returns to the regions of the sky and is not subject to destruction, but being changed by dissolution returns to that property of which it consisted before.' Pythagoras, Empedocles, Epicharmus,⁶ and other physicists and philosophers affirmed that there are four principles: air, fire, earth, water; and that their coherence taking shape according to kind produces attributes in accordance with the variation of species.

¹ In the *LXX Daniel* i. 20, φιλόσοφοι corresponds to μάγοι in Theodotion's version of *Daniel* which from an early date had replaced the *LXX Daniel*. Swete, *Introduction*, 47.

² Plato, *Rep.* 568A.

³ Fr. 836 (Nauck).

⁶ Of Syracuse, comic dramatist and philosopher, met Aeschylus at the court of Hiero I.

- 2 Animadvertimus vero non solum nascentia ex his esse procreata, sed etiam res omnes non ali sine eorum potestate neque crescere nec tueri. Namque corpora sine spiritus¹ redundantia non possunt habere vitam, nisi aer influens cum incremento fecerit auctus et remissiones continenter. Caloris vero si non fuerit in corpore iusta comparatio, non erit spiritus animalis neque erectio firma, cibique vires non poterunt habere coctionis temperaturam. Item si non terrestri cibo membra corporis alantur, deficientur et ita a terreni principii mixtione erunt deserta.
- 3 Animalia vero si fuerint sine umoris potestate, exsanguinata et exsucata a principiorum liquore interarescent. Igitur divina mens, quae proprie necessaria essent gentibus, non constituit difficilia et cara, uti sunt margaritae, aurum, argentum ceteraque, quae neque corpus nec natura desiderat, sed sine quibus mortalium vita non potest esse tuta, effudit ad manum parata per omnem mundum. Itaque ex his, si quid forte deficit in corpore spiritus, ad restituendum aer adsignatus id praestat. Apparatus autem ad auxilia caloris solis impetus et ignis inventus tutiorem efficit vitam. Item terrenus fructus escarum praestans copiis supervacuis desiderationibus alit et nutrit animales pascendo continenter. Aqua vero non solum potus sed infinitas usu praebebendo necessitates, gratas, quod est gratuita, praestat utilitates.
- 4 Ex eo etiam qui sacerdotia gerunt moribus Aegyptiorum, ostendunt omnes res e liquoris potestate consistere. Itaque cum hydria aqua² ad templum

¹ spiritus *Schn* : spiritu *H*.

² hydriâ aqua *Ro* : hydrio quem *H*.

BOOK VIII. PREFACE

2. We observe, however, that things are not only created of them at birth, but also are nourished, grow, and are preserved by their power. For apart from the flow of breath, bodies cannot have life unless the influx of air continually increases inspiration and respiration. If there is not in the body a due provision of heat, there will be neither breath of life nor firm and upright pose, and the properties of food will lack the effect of digestion. Again, if the members of the body are not nourished by the produce of the earth they will waste away, being deprived of the mixture of that element.

3. Animals which lack the water lose their blood and juices, and dry up their liquid part. Therefore the Divine Mind has not made those things which are specially necessary to mankind as inaccessible and expensive as are pearls, gold, silver and the like, which neither our body nor our nature requires, but has poured forth ready to hand through all the world what is necessary for the safety of our mortal life. Therefore, if of these elements there is a need of breath, the air appointed to supply it, does so. The heat of the sun and the invention of fire are ready to help us with warmth and to render our life more safe. Further, the fruit of the earth, surpassing our need of food by abundant supplies, feeds and nourishes animals by unfailing diet. Water, moreover, by furnishing not only drink but all our infinite necessities, provides its grateful utility as a gracious gift.

4. Hence also those who fill priesthoods of the Egyptian tradition¹ show that all things arise from the principle of water. Therefore, after carrying water

¹ Plutarch, *de Iside*, 59. Water is identified with Osiris. Thales is said to have been inspired by Egyptian priests.

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aedemque casta religione refertur, tunc in terra procumbentes manibus ad caelum sublatis inventionis ¹ gratias agunt divinae benignitati.

Cum ergo et a physicis et philosophis et ab sacerdotibus iudicetur ex ² potestate aquae omnes res constare, putavi, quoniam in prioribus septem voluminibus rationes aedificiorum sunt expositae, in hoc oportere de inventionibus aquae, quasque habeat in locorum proprietatibus virtutes, quibusque rationibus ducatur, et quemadmodum ante ³ probetur, scribere.

I

- 1 Est enim maxime necessaria et ad vitam et ad delectiones ⁴ et ad usum cotidianum. Ea autem erit faciliior, si erunt fontes aperti et fluentes. Sin autem non profluent, quaerenda sub terra sunt capita et colligenda. Quae sic erunt experienda, uti procumbatur in dentes, antequam sol exortus fuerit, in locis, quibus erit quaerendum, et in terra mento conlocato et fulto prospiciantur eae regiones; sic enim non errabit excelsius quam oporteat visus, cum erit inmotum mentum, sed libratam altitudinem in regionibus certa finitione designabit. Tunc, in quibus locis videbuntur umores concrispantes et in aera surgentes, ibi fodiatur; non enim in sicco loco hoc potest signum fieri.
- 2 Item animadvertendum est quaerentibus aquam, quo genere sint loca; certa enim sunt, in quibus

¹ inventionis *Ro*: -nibus *H*.

² & potestate *H*.

³ ante *Ro*: into *H*.

⁴ delectiones *H et a. c. G*.

in a vessel to the precincts and temple with pure reverence, they fall upon the ground, raise their hands to heaven and return thanks to the divine goodwill for its invention.

Therefore, inasmuch as physicists philosophers and the clergy judge that everything consists of the principle of water, I thought fit that, having explained in the previous seven volumes the methods of building, I should write in the present volume about the discovery of water, the qualities of its special sources, the methods of water-supply and of testing water before using it.

CHAPTER I

ON FINDING WATER

1. WATER is very necessary for life, for delight, for daily use. Water will be more accessible if the springs flow in the open. But if they do not flow above ground, sources are to be sought and collected underground. The method of trial is to fall on one's face before sunrise in the place where the search is to take place, and placing and supporting one's chin on the ground, to look round the neighbourhood. For when the chin is fixed, the sight will not wander higher than it ought, but will mark the same level throughout the landscape, with a definitely limited height. Thereupon digging is to be carried out where moisture seems to curl upwards and rise into the air; for this indication cannot arise on dry ground.

2. Those who look out for water must also observe the nature of the ground; for there are certain

nascitur. In creta tenuis et exilis et non alta est copia; ea erit non optimo sapore. Item sabulone soluto tenuis, sed inferioris loci invenietur; ea erit limosa et insuavis. Terra autem nigra sudoris et stillae exiles inveniuntur, quae ex hibernis tempestatibus collectae in spissis et solidis locis subsident; haec habent optimum saporem. Glarea vero mediocres et non certae¹ venae reperiuntur; hae quoque sunt egregia suavitate. Item sabulone masculo harenaque carbunculo certiores [et stabiliores]² sunt copiae; eaeque³ sunt bono sapore. Rubro saxo et copiosae et bonae, si non per intervenia dilabantur et liquescant. Sub radicibus autem montium et in saxis silicibus uberiores et affluentiores; eaeque⁴ frigidiores sunt et salubriores. Campestribus autem fontibus salsae, graves, tepidae, non suaves,⁵ nisi quae ex montibus sub terra submanantes erumpunt in medios campos ibique⁶ arborum umbris contectae praestant montanorum fontium suavitatem.

- 3 Signa autem, quibus terrarum generibus supra scriptum est, ea invenientur nascentia: tenuis iuncus, salix erratica, alnus, vitex, harundo, hedera aliaque, quae eiusmodi sunt, quae non possunt nasci per se sine umore. Solent autem eadem in lacunis nata esse, quae sidentes⁷ praeter reliquum agrum excipiunt ex imbris et agris per hiemem propterque capacitatem diutius conservant umorem. Quibus non est

¹ non certae *Joc (Fav., Plin.)*: non incertae *H.*

² et stabiliores *G*: *om. H S.*

³ eaeque *G*: aequae *H.*

⁴ aequae *H.* ⁵ suavis *H.*

⁶ medio campo sibi *que H S.*

⁷ sedentes *H.*

¹ *Creta* = clay from which bricks, etc. are made, Book II. viii. 19.

places where it rises. In clay¹ the supply is thin and scanty and near the surface; this will be not of the best flavour. In loose gravel the supply is scanty but it is found lower down; this water will be muddy and unpleasant. In black earth, moisture and small drops are found; when these gather after the winter rains and settle in hard solid receptacles, they have an excellent flavour. But in gravel small and uncertain currents are found; these also are of unusual sweetness. In coarse gravel, common sand and red sand,² the supply is more certain, and this is of good flavour. The waters from red rock are copious and good, if they do not disperse through the interstices and melt away. At the foot of mountains³ and in flinty rocks water flows more copiously; and this is more cool and wholesome. Springs on level ground are salt, coarse, lukewarm and unpleasant, unless they flow from the mountains underground, and break out in the middle of the fields, and there under the shadows of the trees they furnish the sweetness of mountain springs.

3. The following growths will be found to show where the kinds of soil already described are found; the slender bulrush, the wild willow, the alder, the agnus castus, reeds, ivy and the like which cannot grow without moisture. These plants usually grow in marshy places; for these, settling below the level of the rest of the ground, receive water from the rains and from the rest of the land in winter, and because of their capacity retain the moisture. We must

¹ The pebble beds and the New Red Sandstone of the Triassic series supply abundant water.

² Cretaceous formations containing water are found all along the Apennines.

credendum, sed quibus regionibus et terris, non lacunis, ea signa nascuntur, non sata, sed naturaliter per se procreata, ibi est quaerenda.

4 In quibus si eae significabuntur inventiones, sic erunt experiundae. Fodiatur quoquoersus locus latus ne minus pedes <tres, altus pedes> ¹ quinque, in eoque conlocetur circiter solis occasum scaphium aereum aut plumbeum aut pelvis. Ex his quod erit paratum, id ² intrinsecus oleo ungatur ponaturque inversum, et summa fossura operiatur harundinibus aut fronde, supra terra obruatur; tum postero die aperiatur, et si in vaso stillae sudorisque erunt, is locus habebit aquam.

5 Item si vasum ex creta factum non coctum in ea fossione eadem ratione opertum positum fuerit, si is locus aquam habuerit, cum apertum fuerit, ³ vas umidum erit et iam dissolvetur ab umore. Vellusque lanae si conlocatum erit in ea fossura, insequenti autem die de eo aqua expressa erit, significabit eum locum habere copiam. Non minus si lucerna concinnata oleique plena et accensa in eo loco operta fuerit conlocata et postero die non erit exusta, sed habuerit reliquias olei et enlychni ⁴ ipsaque umida invenietur, indicabit eum locum habere aquam, ideo quod omnis tepor ad se ducit umores. Item in eo loco ignis factus si fuerit et percalfacta terra et adusta vaporem nebulosum ex se suscitaverit, is

6 locus habebit aquam. Cum haec ita erunt pertemp-tata et, quae supra scripta sunt, signa inventa, tum deprimendus est puteus in eo loco, et si erit caput

not rely upon these places, but water is to be sought in those regions and soils other than marshes in which such trees are found naturally, and not artificially planted.

4. When such a discovery is indicated, we must make trials in the following way. A hole is to be dug not less than three feet square and five feet deep, and about sunset a bronze or lead vessel, or a basin, is to be placed there. Whichever it is, must be smeared inside with oil and put upside down, and the top of the hole covered with rushes or leaves; and earth must be thrown above. On the next day it is to be opened, and if there are drops of water and moisture in the vessel, water will be found.

5. Further, if a vessel made of clay, but not burnt, be covered in the same way and put in the pit, if there is water in the place, the vessel will be moist when opened and soon be destroyed by the moisture. Or if a fleece of wool is placed in the hole, and next day water can be squeezed from it, it will show that water is abundant there. Similarly let a lamp be trimmed and filled with oil and lit. If it is covered and put in that place and on the following day it is not burnt out, but has traces of the oil and wick and is itself found moist, it will show that water is found there, because all heat draws moisture to itself. Again, if a fire is made there and the soil which is heated and burnt raises a misty vapour from itself, the place will supply water. 6. When these experiments have been made and the above mentioned signs of water found, a well is to be sunk. If a head of

¹ *add. Phil (ex Fav.).*

² *id S: idque H G.*

³ *cum apertum fuerit om. S (del. G^e).*

⁴ *enlychm Gr: inlychni H S, ≡ lychni G^e.*

aquae inventum, plures circa sunt fodiendi et per specus¹ in unum locum omnes conducendi.

Haec autem maxime in montibus et regionibus septentrionalibus sunt quaerenda, eo quod in his et suaviora et salubriora et copiosiora inveniuntur. Aversi enim sunt solis cursui, et in his locis primum crebrae sunt arbores et silvosae, ipsique montes suas habent umbras obstantes et radii solis non directi perveniunt ad terram nec possunt umores exurere.

- 7 Intervallaque montium maxime recipiunt imbres et propter silvarum crebritatem nives ab umbris arborum et montium ibi diutius conservantur, deinde liquatae per terrae venas percolantur et ita perveniunt ad infimas montium radices, ex quibus profluentes fontium erumpunt fructus.² Campestribus autem locis contrario non possunt habere copias. Nam quaecumque sunt, non possunt habere salubritatem, quod solis vehemens impetus propter nullam obstantiam umbrarum eripit exhauriendo fervens ex planitie camporum umorem, et si quae sunt aquae apparentes,³ ex his, quod est levissimum tenuissimumque et subtili salubritate, aer avocans dissipat in impetum caeli, quaeque⁴ gravissimae duraeque et insuaves sunt partes, eae in fontibus⁵ campestribus relinquuntur.

II

- 1 ITAQUE, quae ex imbris aqua colligitur, salubriores habet virtutes, quod eligitur ex omnibus fontibus

¹ per specus *ed* : perspicuus *H S*, ppsiculus *G*.

² fructus *H (i. marg. G^o)* : ructus *G*.

³ apparantes *H*.

⁴ quaque *H*.

⁵ frontibus *H*.

water is found, several wells are to be sunk round it, and all are to be brought together by underground channels into one place.

Water, however, is to be most sought in mountains and northern regions, because in these parts it is found of sweeter quality, more wholesome and abundant. For such places are turned away from the sun's course, and in these especially are many forest trees; and the mountains themselves have intervening shadows, nor do the sun's rays reach the earth directly and cause the moisture to evaporate.

7. Valleys between mountains are subject to much rain, and because of the dense forests, snow stands there longer under the shadow of the trees and the hills. Then it melts and percolates through the interstices of the earth and so reaches to the lowest spurs of the mountains, from which the product of the springs flows and bursts forth. But on the plains one cannot get supplies of water. And what there is, cannot be wholesome, because, in the absence of shadow, the violent power of the sun catches and drains, by its heat, the moisture from the level fields. And if any water is visible, the air calls out the lightest, thinnest and most subtly wholesome part and dissipates it towards the sky; but the heaviest, the harsh and unpleasant parts, are left in the field springs.

CHAPTER II

ON RAIN-WATER

1. THEREFORE rain-water has more wholesome qualities, because it comes from the lightest and

levissimis subtilibusque tenuitatibus, deinde per aeris exercitationem percolata tempestatibus liquescendo pervenit ad terram. Etiamque non crebriter in campis confluunt imbres, sed in montibus aut ad ipsos montes, ideo quod umores ex terra matutino solis ortu moti cum sunt egressi, in quamcumque partem caeli sunt proclinati, trudent aera; deinde, cum sunt moti, propter vacuitatem loci post se recipiunt aeris ruentis¹ undas. Aer autem, qui ruit, trudens quocumque umorem per vim spiritus impetus et undas crescentes facit ventorum. A ventis autem quocumque feruntur² umores conglobati ex fontibus, ex fluminibus et paludibus et pelago, cum tempore solis colligunt et exhauriunt et ita tollunt in altitudinem nubes. Deinde cum aeris unda nitentes, cum perventum ad montes, ab eorum offensa et procellis propter plenitatem et gravitatem liquescendo disparguntur³ et ita diffunditur in terras.

3 Vaporem autem et nebulas et umores ex terra nasci haec videtur efficere ratio, quod ea habet in se et calores fervidos et spiritus inmanes refrigerationesque et aquarum magnam multitudinem. Ex eo, cum refrigeratum noctu sol oriens impetu tangit orbem terrae et ventorum flatus oriuntur per tenebras, ab umidis locis egrediuntur in altitudinem nubes. Aer autem cum a sole percalefactus⁴ cum rationibus tollit ex terra umores, licet ex balineis⁴ exemplum capere. Nullae enim camerae, quae sunt

¹ ruentis Ro: ruentes H.

² feruntur H^o: feruuntur HG.

³ dispargunt H.

⁴ percalcefactus H.

¹ cum tempore is doubtful; cf. *nec vernus melius floret cum tempore ramus*, ps-Cypr. de resurrectione 224.

most finely tenuous of all sources; then filtering through moving air, it liquefies in storms and so reaches the earth. Further, it is not often that rain showers gather in the plains, but rather on the mountains or near them. For moisture rising from the earth being moved by the rising sun at dawn, thrusts the air into whatever part of the sky it tends. Thereupon the moisture thus moved, because of the vacuum, receives behind it the waves of rushing air. 2. Now the air which rushes on, thrusting the moisture in whatever direction, by the violence of the blast causes the rising force and undulations of the winds. Whithersoever the wind carries the massed moisture from springs, from rivers and marshes and the sea, the moisture under the sun's influence¹ is collected and drawn forth, and the clouds are raised on high. Then the clouds, supported on the wave of air, meet the resistance of the mountains and, becoming liquid in rain-storms, by their fullness and weight, break and their water is poured over the fields.

3. Now vapour and clouds and moisture seem to rise from the earth, for this reason that the earth contains both fervid heat and huge blasts of air, coldness and a large amount of water. Hence when the world is cooled by night, and the rising sun touches it by its force, and gusts of wind rise up through the darkness, the clouds rise on high from the damp places. In that the air warmed by the sun through its effect raises moisture from the earth, we can find a parallel in the baths. 4. For the vaulted chambers² which enclose a hot bath cannot

¹ Book V. x. 3.

caldariorum, supra se possunt habere fontes, sed caelum, quod est ibi¹ ex praefurniis ab ignis vapore percalefactum, corripit ex pavementis aquam et aufert secum in camararum curvaturas et sustinet, ideo quod semper vapor calidus in altitudinem se trudit. Et primo non remittit propter brevitatem, simul autem plus umoris habet congestum, non potest sustinere propter gravitatem, sed stillat supra lavantium capita. Item² eadem ratione caelestis aer, cum ab sole percepit calorem, ex omnibus locis hauriendo tollit umores et congregat ad nubes. Ita enim terra fervore tacta eicit umores, etiam corpus hominis ex calore emittit³ sudores.

6 Indices autem sunt eius rei venti, ex quibus qui a frigidissimis partibus veniunt procreati, septentrio et aquilo, extenuatos⁴ siccitatibus in aere flatus spirant; auster vero et reliqui, qui a solis cursu impetum faciunt, sunt umidissimi et semper adportant⁵ imbres, quod percalefacti ab regionibus fervidis adveniunt, ex omnibus⁶ terris labentes eripiunt umores et ita eos profundunt ad septentrionales regiones.

6 Haec autem sic fieri testimonio possunt esse capita fluminum, quae orbe terrarum chorographiis picta itemque scripta plurima maximaque inveniuntur egressa ad septentrionem. Primumque in India Ganges et Indus ab Caucasio monte oriuntur; Syria Tigris et Euphrates; Asiae item,⁷ Ponto Borysthenes, Hypanis, Tanais; Colchis⁸ Phasis; Gallia Rhodanus;

¹ ibi *ed*: ubi *H*.

² item *S*: idem *H*.

³ emittit *h*: emit ut *H*.

⁴ & tenuatos *H*.

⁵ adportent *H*.

⁶ omnis *H*.

⁷ item *S G*: idem *H G*.

⁸ conchis *H S*: colchys *G*.

have springs above them, but the ceiling which is there heated with hot air from the furnace, takes up water from the pavement, and carrying it up to the curved surface of the vaulting, supports it, because warm vapour always thrusts upward. At first, owing to the slight amount, the ceiling does not drip, but as soon as it has collected more moisture, it cannot keep the water up because of its weight, but sprinkles it on the heads of the bathers. In the same way the air of the sky, receiving heat from the sun, draws moisture from all directions, lifts it and assembles it into clouds. For the earth when it is touched by heat casts forth moisture,—the human body also sweats from warmth.

5. This is proved by the winds. For those which originate and blow from the coldest quarters, the north and north-east, bring currents of air which are rarefied by their dryness; but the south wind and the rest, which attack us from the south, are very moist and always bring rains, because they come warmed from the hot regions; and as they fall, they take up the moisture everywhere and so pour it forth towards the north.

6. A proof of this is found in the sources of rivers, as they are painted on maps of the world,¹ and as they are described.² The most numerous and the largest are found to issue in the north. First of all in India, the Ganges and Indus rise in the Caucasus; in Syria, the Tigris and Euphrates; in Asian Pontus, the Dnieper, the Boug and the Don; in Colchis, the Phasis; in Gaul, the Rhone; in Celtic territory, the

¹ An allusion to the map of Agrippa in the Porticus Vipsania. Plin. *N.H.* III. 17.

² An allusion to the geographical work of Agrippa.

Celtica Rhenus; citra Alpīs Timavos et Padus; Italia Tiberis; Maurusia, quam nostri Mauretāniam appellant, ex monte Atlante Dyris,¹ qui ortus ex septentrionali regione progreditur per occidentem ad lacum Eptagonum et mutato nomine dicitur Agger, deinde ex lacu Eptabolo sub montes desertos subterfluens per meridiana loca manat et influit in Paludem quae appellatur, circumcingit Meroen, quod est Aethiopum meridianorum regnum, ab hisque paludibus se circumagens per flumina Astan-sobam² et Astoboam³ et alia plura pervenit per montes ad cataractam ab eoque se praecipitans per septentrionalem pervenit inter Elephantida et Syenen⁴ Thebaicosque in Aegyptum campos et ibi Nilus appellatur.

7 Ex Mauretania autem caput Nili profluere ex eo maxime cognoscitur, quod ex altera parte montis Atlantis alia capita item profluentia ad occidentem Oceanum, ibique nascuntur ichneumones, crocodili, aliae similes bestiarum pisciumque naturae praeter hippopotamos.

8 Ergo cum omnia flumina magnitudinibus in orbis terrarum descriptionibus a septentrione⁵ videantur profluere Afrique campi, qui sunt in meridianis partibus subiecti solis cursui, latentes penitus habent umores nec fontes crebros amnesque raros, relinquitur,

¹ dryis *H.* ² hastansoban *H.*, -bā *S.*

³ astoboam *G.*: adstoboam *H.* ⁴ suenen *H.*

⁵ aseptentrionē *H.*

¹ Addiris, *Plin. N.H. V. 13.* Dyris = the name of Mt. Atlas, *Strabo*, 825.

² The course of the Nile is now described.

Rhine; south of the Alps, the Timavo and Po; in Italy, the Tiber; in Morocco, which we call Mauretania, the Dyris¹ comes from Mount Atlas. This river² rises in the north, turns to the west to Lake Eptagonus³ and there, changing its name, it is called Agger.⁴ Thence it flows from Lake Eptabolos⁵ under mountains of the desert through the south and flows into the Marsh⁶ so-called. It then winds round Meroe, which is the Southern Ethiopian kingdom, and turning from these marshes through the rivers Astansobas and Astoboas⁷ and many others, it arrives through the mountains at the Cataract. Thence rushing northwards it passes into Egypt, between Elephantis and Syene and the Theban plain, and is there called the Nile.

-7. What shows more than anything else that the source of the Nile rises in Mauretania, is, that on the other side of Mount Atlas there are other springs flowing to the Western Ocean, and in them are found the ichneumon, the crocodile and other animals and fishes of a like nature, but not the hippopotamus.⁸

8. Since then all rivers of magnitude seem according to the descriptions of the world to flow from the north, and the plains of Africa, which are on the south subject to the sun's course, have their moisture deeply hidden and few fountains or rivers,

¹ Probably the Albert Nyanza.

² Ger, Plin. *N.H.* V. 14. *Gir* in Berber signifies 'running water.'

³ Probably the Victoria Nyanza.

⁴ Probably the sudd of the White Nile.

⁵ Atbara. These descriptions were probably due to traders journeying from Zanzibar.

⁶ The hippopotamus is found in the Niger as well as in the upper waters of the Nile.

VITRUVIUS

uti multo meliora inveniantur capita fontium, quae ad septentrionem aut aquilonem spectant, nisi si inciderint in sulphureum locum aut aluminosum seu bituminosum. Tunc enim permutantur <et>¹ aut calidae aquae aut frigidae odore malo et sapore
9 profundunt fontes. Neque enim calidae aquae est ulla proprietas, sed frigida aqua, cum incidit percurrens in ardentem locum, effervescit et percalefacta egreditur per venas extra terram. Ideo diutius non potest permanere, sed brevi spatio fit frigida. Namque si naturaliter esset calida, non refrigeraretur calor eius.² Sapor autem et odor et color³ eius non restituitur, quod intinctus et commixtus est propter naturae raritatem.

III

- 1 SUNT autem etiam nonnulli fontes calidi, ex quibus profluit aqua sapore optimo, quae in potione ita est suavis, uti nec fontalis ab Camenis nec Marcia saliens desideretur. Haec autem ab natura perficiuntur his rationibus. Cum in imo per alumen aut bitumen seu sulphur ignis excitatur, ardore percandefacit terram, quae est supra se; autem⁴ fervidum emittit in superiora loca vaporem, et ita, si qui in his locis, qui sunt supra, fontes dulcis aquae nascuntur, offensi eo vapore effervescunt inter venas et ita profluunt incorrupto sapore.

¹ *add. Joc.* ² *calcoleius H.*

³ *color e₂ Sulp: calor H.*

⁴ *fortasse soloecismus: cf. autem non habuit, Quint. I. 5. 39.*

¹ Lucretian phrase; cf. *textura praedita rara*, iv. 196. Vitruvius has *rara proprietas*, Book II. iii. 4.

it remains that much better sources are found to the north and north-east, unless they come upon sulphur, alum or bitumen. For then they are changed; and either hot or cold, they send forth springs of a bad flavour or odour. 9. For there is no special character attaching to hot water, but when cold water, as it runs, comes upon hot ground, it seethes and comes out warm through the cracks above ground. Therefore it cannot retain its heat, but soon becomes cold. For if it were naturally warm, its warmth would not be subject to chill. But taste and smell and colour are not surrendered, because it is steeped and blended with these qualities owing to its rarefied texture.¹

CHAPTER III

ON THE NATURE OF DIFFERENT WATERS

1. THERE are some hot springs from which water flows of excellent flavour and so pleasant to drink that we miss neither the Fountain of the Camenae² nor the conduit of the Marcian Aqueduct.³ Hot springs arise naturally in the following way. Fire arises underground owing to alum or bitumen or sulphur, and by its heat makes the soil above it to glow. It further sends a warm vapour to the surface of the ground, and whatever springs of sweet water rise in such places, meeting this vapour they surge forth between the cracks and flow without damage to their flavour.

¹ On the south side of the Caelian Hill, Platner, 89. Frontin. *Aquaed.* 4.

² 'Finest of all water,' Plin. *N.H.* XXXI. 41.

2 Sunt etiam odore et sapore non bono frigidi fontes, qui ab inferioribus locis penitus orti per loca ardentia transeunt et ab eo per longum spatium terrae percurrentes refrigerati perveniunt supra terram sapore odore coloreque corrupto, uti in Tiburtina via flumen Albula et in Ardeatino fontes frigidi eodem odore, qui sulphurati dicuntur, et reliquis locis similibus. Hi autem, cum sunt frigidi, ideo videntur aspectu fervere, quod, cum in ardentem locum alte penitus inciderunt, umore et igni inter se congruentibus offensa vehementi fragore validos recipiunt in se spiritus, et¹ ita inflati vi venti coacti bullientes crebre per fontes egrediuntur. Ex his autem qui non sunt aperti, sed a² saxis continentur, per angustas venas vehementia spiritus extruduntur ad summos grumorum tumulos.

3 Itaque qui putant³ se altitudine, qua sunt grumi, capita fontium posse⁴ habere, cum aperiunt fossuras latius, decipiuntur. Namque uti aeneum vas non in summis labris plenum sed aquae mensurae suae capacitatis habens tribus duas partes operculumque⁵ in eo conlocatum, cum ignis vehementi fervore tangatur, percalefieri cogit aquam, ea autem propter naturalem raritatem in se recipiens fervoris validam inflationem non modo implet vas, sed spiritibus extollens operculum et crescens abundat, sublato autem operculo emissis inflationibus in aere patenti rursus ad suum locum residit:⁶ ad eundem modum ea capita fontium cum sunt angustis con-

¹ et *ed* : ut *H.*

² a *Schn* : aut *H.*

³ qui putant *rec* : quantant *H.*

⁴ posse *Joc* : fosse *H.*

⁵ operculum *ed* : opertum *H.*

⁶ resedit *H.*

¹ Sulphur baths still used.

2. There are also cold springs not of pleasant smell or taste, which, rising far below, pass through hot soil, and thereupon running a long distance are chilled and reach the surface with damage to their flavour, their smell and colour; such as the river Albula¹ on the Via Tiburtina,² and the cold springs near Ardea, with the same smell, and called sulphur springs, and in other like places. Now these springs, being cold, have the appearance of bubbling, because when, deep down, they come upon a hot place, the fire and water meet; and because of the collision, the springs take up with a loud noise the violent currents of air. They are thus forced by the power of the wind driven into them, to issue with much bubbling through the fountains. But those which have no outlet and are contained by rocks, are driven forth through narrow passages by the vehemence of the air-currents to the tops of hillocks.

3. Hence those who think that they can have fountain-heads of the same height as the hills find their mistake when they open out their trenches. For instance, let a bronze vessel be filled not to the brim but holding two-thirds, by measure, of its capacity of water; and let a lid be placed upon it. When it is subjected to the vehement heat of the fire, it makes the water boil. Yet, owing to its natural penetrability, it takes up a strong inflation of the heat, and not only fills the vessel but, raising the lid with the currents of air, it expands and boils over. When, however, the lid is removed, the steam passes into the open and the water settles down into its own place again. In the same way when fountain-heads are forced along narrow channels, the

¹ Road to Tivoli 16 miles north-east of Rome.

pressa, ruunt ¹ in summo spiritus aquae bullitus, simul autem sunt latius aperti, exanimati per raritates liquidae potestatis residunt et restituuntur in libramenti proprietate.

4 Omnis autem aqua calida ideo [quod] ² est medicamentosa, quod in pravis rebus percocta aliam virtutem recipit ad usum. Namque sulphurosi fontes nervorum labores reficiunt percalefaciendo exurendoque caloribus e corporibus umores vitiosos. Aluminosi autem, cum dissoluta membra corporum paralysi aut aliqua vi morbi receperunt, fovendo per patentem venas refrigerationem ³ contraria caloris ⁴ vi reficiunt, et hoc continenter restituuntur in antiquam membrorum curationem. Bituminosi autem interioris corporis vitia potionibus purgando solent mederi.

5 Est autem aquae frigidae genus nitrosum, uti Pinnae Vestinae, Cutiliis aliisque locis similibus, quae potionibus depurgat per alvumque transeundo etiam strumarum minuit tumores. Ubi vero aurum, argentum, ferrum, aes, plumbum reliquaeque res earum similes fodiuntur, fontes inveniuntur copiosi, sed hi maxime sunt vitiosi. Habent enim vitia aquae calidae sulphur alumen bitumen, eademque, ⁵ per potiones cum in corpus iniit et per venas permanendo nervos attingit et artus, eos durat inflando. Igitur nervi inflatione turgentes e longitudine contrahuntur et ita aut nervicos aut podagricos efficiunt homines,

¹ compressa ruunt *G* : conpraesserunt *H*.

² *del. rec.* ³ refrigerationem *ed* : -ne *H*.

⁴ caloris vi *Joc* : calore sui *H*.

⁵ eademque *Gr* : eademque *H S*.

¹ Favourite phrase of Lucretius : *plumbi potestas*, v. 1242.

² Hippocrates, *de aere aquis locis*, is followed in some places by Vitruvius.

currents of air rush in bubbles through the water on the top; as soon as the channels are opened out wider, the springs part with the air through the pores of the liquid potency,¹ and, settling down, they regain their proper level.

4. As to the curative² power of warm springs, the reason is that the water being thoroughly heated in vitiated soils, takes up an additional and useful quality. For sulphur springs refresh muscular weakness by heating and burning poisonous humours from the body. Alum springs affect parts of the body which are dissolved³ by paralysis or some stroke of disease; they warm through the open pores and overcome the cold by the opposing power of the heat, and thus forthwith the diseased parts are restored to their ancient health. Bitumen⁴ springs furnish draughts which purge and heal interior defects.

5. There is an alkaline sort of cold spring, as at Penne and Cutili⁵ and other like places, which, when taken, purges, and passing through the intestines, also lessens scrofulous tumours. But when gold, silver, iron, copper, lead and the like are mined, abundant springs are found, but mostly impure. They have the impurities of hot springs, sulphur, alum, bitumen; and when the water is taken into the body and, flowing through the vessels, reaches the muscles and joints, it hardens them by expansion. Therefore the muscles swelling with expansion are contracted in length. In this way men suffer from cramp or gout,

¹ *Vulg. II. Cor. v. 1, si terrestris domus . . . dissolvatur.*

⁴ Berkeley, *Siris*, deals with curative virtues of tar, a form of bitumen.

⁵ Towns in the Abruzzi.

ideo quod ex durissimis et spissioribus¹ frigidissimisque rebus intinctas habent venarum raritates.

6 Aquae autem species est, quae cum habeat non satis perlucas et ipsa uti flos natat in summo, colore similis vitri purpurei. Haec maxime considerantur Athenis. Ibi enim ex eiusmodi locis et fontibus in asty et ad portum Piraeum ducti sunt salientes, e quibus bibit nemo propter eam causam, sed lavationibus² et reliquis rebus utuntur, bibunt autem ex puteis et ita vitant eorum vitia. Troezeni non potest id vitari, quod omnino aliud genus aquae non reperitur, nisi quod *cibdeli* habeant; itaque in ea civitate aut omnes aut maxima parte sunt pedibus vitiosi. Cilicia vero civitate³ Tarso flumen est nomine Cydnos, in quo podagrici crura macerantes levantur dolore.

7 Sunt autem et alia multa genera, quae habent suas proprietates, ut in Sicilia flumen est Himeras, quod, a fonte cum est progressum, dividitur in duas partes; quae pars profluit contra Etruriam, quod per terrae dulcem sucum percurrit, est infinita dulcedine, quae altera parte per eam terram currit, unde sal foditur, salsum habet saporem. Item Paraetonio et quod est iter ad Ammonem et Casio⁴ ad Aegyptum lacus sunt palustres, qui ita sunt salsi, ut habeant insuper se salem congelatum. Sunt autem et aliis pluribus locis et fontes et flumina <et>⁵ lacus, qui per salifodinas percurrentes necessario salsi perficiuntur.

8 Alii autem per pingues terrae venas profluentes uncti oleo fontes erumpunt, uti Solis, quod oppidum

¹ spissioribus *e₂ ed*: spissionibus *H.*

² labationibus *H.*

³ civitate *Joc*: civitas *H.*

⁴ cassio *H S.* ⁵ *add. ed.*

because they have the pores of the vessels saturated with hard, thick and cold particles.

6. There is a kind of water which has pores insufficiently clear; a foam floats on the top, in colour like blue glass. This is especially seen at Athens where conduits¹ from such places and fountains are taken to the city and the Piræus. No one drinks from it because of the reason given, but they use it for baths and so forth. They drink from wells and thus avoid its ill effect. This cannot be avoided at Troezen, because no other water is found there at all, except what is furnished by polluted springs; therefore in that city either all or the greatest part suffer from their feet. In the Cilician city Tarsus there is a river, Cydnus by name, in which gouty persons bathe their legs to relieve the pain.

7. There are many other kinds of water which have their properties. In Sicily, the river Himeras,² on leaving its source, divides into two branches: one flows towards the coast which faces Etruria and is of infinite sweetness, because it runs through the sweet juices of the soil; the other stream which runs through the other part where there are salt mines has a salt flavour. At Paraetonium and on the road to the oracle of Ammon, and at Mt. Casius in Egypt, there are marshy lakes which contain so much salt that it cakes over them. In many other places there are springs and rivers and lakes which run through salt mines and necessarily are made salt.

8. Other fountains flow through rich veins of soil and spring up with an oily surface. At Soli, a town

¹ Esp. the Enneacrunos, *J.H.S.* XIII. 141.

² Northern branch, the Fiume Grande; the southern, the Fiume Salso.

est Ciliciae, flumen nomine Liparis, in quo natantes aut lavantes ab ipsa aqua unguuntur. Similiter Aethiopiae lacus est, qui unctos homines efficit, qui in eo nataverint,¹ et India, qui sereno caelo emittit olei magnam multitudinem, item Carthagini fons, in quo natat insuper oleum, odore uti scribe citreo; quo² oleo etiam pecora solent ungui.³ Zacyntho⁴ et circa Dyr-rachium⁵ et Apolloniam fontes sunt, qui picis magnam multitudinem cum aqua evomunt. Babylone⁶ lacus amplissima magnitudine, qui *limne asphaltitis*⁷ appellatur, habet supra natans liquidum bitumen; quo⁸ bitumine et latere testaceo⁹ structum murum Sameram is circumdedit Babylonem. Item Iope¹⁰ in Syria Arabiaque Numidarum¹¹ lacus sunt inmani magnitudine, qui emittunt bituminis maximas moles, quas diripiunt qui habitant circa.

9 Id autem non est mirandum; nam crebrae sunt ibi lapidicinae bituminis duri. Cum ergo per bituminosam terram vis erumpit aquae, secum extrahit et, cum sit egressa extra terram, secernitur et ita reicit ab se bitumen. Etiamque est in Cappadocia in itinere, quod est inter Mazaca et Tyana,¹² lacus amplius, in quem lacum pars sive harundinis sive alii generis si dimissa fuerit et postero die exempta, ea pars, quae fuerit exempta, invenietur lapidea, quae autem pars extra aquam manserit, permanet in sua proprietate.

10 Ad eundem modum Hierapoli Phrygiae effervet aquae calidae multitudo, e quibus circum hortos et

¹ nataverit *H.*

² quod *H.*

³ ungui *S*: ungeri *H.*

⁴ zachinto *H.*

⁵ dirrachium *H.*

⁶ babilone *H.*

⁷ limnea spartacis *H* (*corr. Schott*).

⁸ quo *S*: quod *H.*

⁹ testaceo *e*₂: testatio *H.*

¹⁰ Iope *e*₂ (*schol*): tope *H.*

of Cilicia, there is a river named Liparis, and those who swim or wash in it are oiled by the water. There is also a lake of Ethiopia which anoints men who swim in it, and another in India which in clear weather produces a great amount of oil. There is also a spring at Carthage¹ on which there floats an oil with the perfume of cedar-shavings, and with this oil, sheep are usually dressed. In Zacynthus and round Dyrrachium and Apollonia² are springs which discharge with the water a great amount of pitch. At Babylon there is a lake of wide extent which is called the Asphalt Lake, with liquid bitumen floating on it. Semiramis built a wall round Babylon of this bitumen and burnt-brick. At Joppa in Syria, also, and in Nomad³ Arabia are lakes of immense size producing much bitumen which is gathered by the neighbouring tribes.

9. This is not surprising, because there are many quarries of hard bitumen there. When, therefore, a spring of water rushes through the bituminous land, it draws the bitumen with it, and passing outside, the water separates and deposits the bitumen. Again, in Cappadocia, on the road between Mazaca⁴ and Tyana, there is a great lake; if part of a reed or any other substance is let fall into it and taken out the next day, it is turned to stone, and the part which remains outside the water stays as it is.

10. In the same way at Hierapolis in Phrygia⁵ abundance of hot water boils up, from which a supply

¹ Arist. *Mirab.* 113.

² *Ibid.* 127.

³ Cf. Luc. iv. 677: *Numidaeque vagi.*

⁴ Received the name Caesarea A.D. 18.

⁵ Strabo, 629.

¹¹ numidarum *H*: cf. *Paulus s.v. numidas dicimus quos Graeci nomadas.*

¹² tuana *H.*

vineas fossis ductis inmittitur; haec autem efficitur post annum crusta lapidea. Ita quotannis dextra ac sinistra margines ex terra faciundo inducunt eam et efficiunt in his¹ crustis in agris saepta. Hoc autem ita videtur naturaliter fieri, quod in is locis et ea terra, quibus is nascitur, sucus subest coaguli naturae similis; deinde cum commixta vis egreditur per fontes extra terram, a solis et aeris calore² cogitur

- 11 congelari, ut etiam in areis salinarum videtur. Item sunt ex amaro suco terrae fontes exeuntes vehementer amari, ut in Ponto est flumen Hypanis.³ A capite profluit circiter milia XL sapore dulcissimo; deinde, cum pervenit ad locum, qui est ab ostio ad milia CLX, admiscetur ei fonticulus⁴ oppido quam parvolus. Is cum in eum influit, tunc tanta magnitudine fluminis facit amaram, ideo quod per id genus terrae et venas, unde sandaracam fodiunt,⁵ ea⁶ aqua manando perficitur amara.

- 12 Haec autem dissimilibus saporibus a terrae proprietate perficiuntur, uti etiam in fructibus videtur. Si enim radices arborum aut vitium aut reliquorum seminum non ex terrae proprietatibus sucum capiendo ederent fructus, uno genere essent in omnibus locis et regionibus omnium sapes. Sed animadvertimus insulam Lesbon vinum protropum,⁷ Maeoniam⁸ Catacecaumeniten,⁹ Lydiam Tmoliten,¹⁰

¹ in his *H*: *Sem. cf. in gladio Luc. XXII. 49.*

² calor *H*.

³ Hypanis *Joc*: hipanis *H S*, Hispanis *e₂ Sulp.*

⁴ fonticulos *H*.

⁵ fodiunt *Müller-Str.*: fodiuntur *H*.

⁶ ea *Joc*: & *H*. ⁷ protropum *Joc*: protyrum

⁸ Maeoniam *Phil*: maloniam *H*.

⁹ catacecaumeniten *Joc*: catacaecaumen. item *H*.

¹⁰ Tmoliten *Phil*: moliton *H*.

is taken by channels round the orchards and vineyards. After a year the water leaves a stony crust. So every year they make banks of soil to the right and left, let in the water, and with the incrustations build enclosures in the fields. The cause of this seems to be natural, in that in these places and in the soil where this happens there is a fluid like the nature of rennet; thereupon when this potency is blended and comes above ground in the springs, it is solidified by the heat of the sun and air, as appears in salt pits. 11. There are also sources arising from the bitter juice of the soil and exceedingly bitter, like those of the Boug. This river flows about 40 miles from its source with very sweet water. Then, when it reaches a spot 160 miles from its mouth, it is joined by a quite small spring. On flowing into the river it makes the broad stream bitter; and this is because the water is made bitter by flowing through the kind of soil and the veins of earth from which they mine red lead.¹

12. These also acquire different flavours from the properties of the soil, as we observe in the case of fruits. For if the roots of trees or vines or other plants² did not produce their fruits by absorbing their juice from the properties of the soil, the flavour of each species would be the same in every district and region.³ But we observe the island of Lesbos and the Protropos⁴ (a sweet wine); Maeonia and the Catacecaumenite,⁵ Lydia and the Tmolite,⁶ Sicily and

¹ Book VII. xii. 2.

² *Semen* in Hebrew sense = 'planting,' *Vulg. Isa.* XVII. 11 *al.*

³ Vitruvius sees a relation between flora and fauna and climate.

⁴ Athen. 45E.

⁵ Praised by Strabo, 628.

⁶ Plin. *N.H.* XIV. 74.

Siciliam Mamertinum, Campaniam Falernum, in Terracinam et Fundis Caecubum¹ reliquisque locis pluribus innumerabili multitudine genera vini virtutesque procreari. Quae non aliter possunt fieri, nisi, cum terrenus umor suis proprietatibus saporis² in radicibus sit infusus, enutrit materiam, per quam egrediens ad cacumen profundat proprium loci et generis sui fructus saporem.

- 13 Quodsi terra generibus umorum non esset dissimilis et disparata, non tantum in Syria et Arabia in harundinibus et iuncis³ herbisque omnibus essent odores, neque arbores turiferae, neque piperis darent bacas, nec murrae glaeblulae, nec Cyrenis in ferulis laser nasceretur, sed in omni terra regionibus eodem genere⁴ omnia procrearentur. Has autem varietates regionibus et locis inclinatio mundi et solis impetus propius⁵ aut⁶ longius cursum faciendo tales efficit terrae umorisque qualitates nec solum in his rebus, sed etiam in pecoribus et armentis haec non ita similiter efficerentur, nisi proprietates singularum terrarum in generibus⁷ ad solis potestatem temperarentur.⁸

- 14 Sunt enim Boeotiae⁹ flumina Cephisos et Melas, Lucanis Crathis,¹⁰ Troia Xanthus inque agris Clazomeniorum et Erythraeorum et Laodicensium fontes. Ad flumina cum pecora suis temporibus anni parantur ad conceptionem partus, per id tempus adiguntur¹¹ eo cotidie potum, ex coque, quamvis¹² sint alba,

¹ Caecubum *ed*: caesibum *H*.

² saporis *rec*: -res *H*.

³ iuncis *Joc*: vineis *H*.

⁴ eodem genera *H*, eadem genera *S*.

⁵ propius *H*.

⁶ aut *E*: ut *H G S*.

⁷ ingeneribus *H S*: inregionibus *E G*.

⁸ temperarentur *S*: perarentur *H*.

⁹ boetiae *H*.

¹⁰ Crathis *ed*: aeraris *H*.

¹¹ adiguntur *E*: adicuntur *H G*, adiciuntur *S*.

¹² qua vis *H*.

the Mamertine,¹ Campania and the Falernian, at Terracina and Fundi the Caecuban, and in many other places kinds and flavours of wine are produced in a countless multitude.² This would not happen unless the juices of the soil, being infused with their characteristic flavour into the roots, fed the tree, and rising to the top, produced the flavour proper to the kind of vine and the locality.

13. For unless the soil were unlike and disparate in its juices, not only in Syria and Arabia would there be perfumes in the reeds, rushes, and all herbs, nor incense-bearing trees; nor would they yield pepper berries, nor would there grow flakes of myrrh; nor in Cyrene would the assafetida grow in the stalks of silphium. But in every land and region everything would be produced of the same kind. On the other hand, these varieties are produced in regions and localities by the climate and the nearer or more distant course of the sun, and are made such by the qualities of the juices of the soil. To go beyond these, the like differences would not arise in flocks and herds unless the properties of the several soils in their own kinds were acquired according to the sun's power.

14. For in Boeotia are the rivers Cephissus and Melas; among the Lucanians, the Crathis; in Troy, the Xanthus; in the territories of Clazomenae, Erythrae and of Laodicea, there are springs. When the cattle in their own season are about to bring forth, they are taken daily during that time of the year to the river to drink. Thereby, although they are maybe white, they bring forth young in some

¹ If kept, lost its flavour, Mart. XIII. 117.

² For Roman wines, Plin. *N.H.* XIV. 59 ff.

procreant aliis locis leucophaea, aliis locis pulla, aliis coracino colore. Ita proprietas liquoris, cum inſit in corpus, proſeminat intinctam ſui cuiusque generis qualitatem. Igitur quod in campis Troianis proxime flumen armenta rufa et pecora leucophaea nascuntur, ideo id flumen Ilienses¹ Xanthum appellaviſſe dicuntur.

- 15 Etiamque inveniuntur aquae genera mortifera, quae per maleficum ſucum terrae percurrentia recipiunt in ſe vim venenatam, uti fuiſſe dicitur Terracinae² fons, qui vocabatur Neptunius, ex quo qui biberant imprudentes, vita privabantur; quapropter antiqui eum obſtruxiſſe dicuntur. Et Chrobsi Thracia³ lacus, ex quo non ſolum qui biberint, moriuntur, ſed etiam qui laverint.⁴ Item in Theſſalia fons eſt profluens, ex quo fonte nec pecus ullum guſtat nec beſtiarum genus ullum propius⁵ accedit; ad quem fontem proxime eſt arbor florens purpureo colore.

- 16 Non minus in Macedonia quod loci ſepultus eſt Euripides, dextra ac ſiniſtra monumenti adveni- entes duo rivi concurrunt. In unum, viatores pransi- tare⁶ ſolent propter aquae bonitatem, ad rivum autem, qui eſt ex altera parte monumenti, nemo accedit, quod mortiferam aquam dicitur habere. Item eſt in Arcadia Nonacris⁷ nominata terrae regio, quae habet in montibus ex ſaxo ſtillantes frigidiſſimos umores. Haec autem aqua⁸ *Stygos Hydor* nominatur, quam neque argentum neque aeneum nec ferreum vas poteſt ſuſtinere, ſed diſſilit

¹ nilienses *H S.*

² terrae cinae *H.*

³ thratia *H S.*

⁴ laberint *H.*

⁵ proprius *H.*

⁶ pransitare *Joc* : transitare *H.*

⁷ non agris *H.*

⁸ aquas tyglos hydor *H* : (*corr. ed.*)

places of a dun colour, in other places of dark grey, in others raven-black. Thus the property of the liquid when it enters the body produces the kind of quality with which it is tintured. Therefore the Trojans are said to have given the name Xanthus¹ or Chestnut to the river which flows in the plains of Troy, because in its neighbourhood the cattle are red and the sheep of a light brown colour.

15. Kinds of water are also found which cause death; these run through dangerous juices of the soil and acquire a poisonous property. Such is said to have been the spring at Terracina which was called Neptune's; people who drank of it unwittingly lost their lives. For this reason, the ancients are said to have stopped it up. At Chrobs² in Thrace there is a lake which brings death not only to those who drink of it, but to those who bathe in it. There is also, in Thessaly,³ a running spring of which sheep do not taste, nor do wild animals approach it; near the spring is a tree bearing a purple flower.

16. Again, at the tomb of Euripides in Macedonia, two streams flowing to the right and the left of the monument come together. At the one stream, travellers recline and take their lunch because of the goodness of the water; but no one approaches the stream on the other side of the monument, because it is said to have poisonous water. There is also in Arcadia a district called Nonacris,⁴ where among the hills icy-cold water drips from the rock. This is called the Water of Styx. Neither vessels of silver, nor of bronze, nor of iron can contain it, but it bursts

¹ *Ξανθαὶ ἵπποι* = chestnut mares, Hom.

² Arist. *Mirab.* 121.

³ At Tempe, Plin. *N.H.* XXXI. 28. ⁴ Paus. VIII. 18. 4.

et dissipatur. Conservare autem eam et continere nihil aliud potest nisi mulina ungula, quae etiam memoratur ab Antipatro in provinciam¹ ubi erat Alexander, per Iollam filium perlata² esse et ab eo ea aqua regem esse necatum.

- 17 Item Alpibus in Cotti³ regno est aqua; qui gustant, statim concidunt. Agro autem Falisco via Campana in campo Corneto est lucus, in quo fons oritur; ubique avium et lacertarum reliquarumque serpentium ossa iacentia apparent.

Item sunt nonnullae acidae venae fontium, uti Lyncesto et in Italia Velino,⁴ Campania Teano aliisque locis pluribus, quae hanc habent virtutem, uti calculos, in vesicis qui nascuntur in corporibus
18 hominum, potionibus discutiant. Fieri autem hoc naturaliter ideo videtur, quod acer et acidus sucus subest in ea terra, per quam egredientes venae intinguntur acritudine, et ita, cum in corpus inierunt, dissipant quae ex aquarum subsidentia in corporibus et concrescentia offenderunt. Quare autem discutiantur ex acidis eae res, sic possumus animadvertere. Ovum in aceto si diutius positum fuerit, cortex eius mollescit⁵ et dissolvitur. Item plumbum, quod est lentissimum et gravissimum, si in vase conlocatum fuerit et in eo acetum suffusum, id autem opertum et oblitum erit, efficietur, uti plumbum dissolvatur, et fiet cerussa.

- 19 Eisdem rationibus aes, quod etiam solidiore est

¹ provinciam *ed*: -cia *H*.

² perlata *Laet*: -tum *H*.

³ Cotti *Joc*: crobi *H*.

⁴ Velino *Budaeus* (*Plin.* XXXI. 9): vienna *H*.

⁵ mollescit *H S*.

¹ *Plut. Alex.* 74.

the vessels and is lost. Nothing but the hoof of a mule can contain and keep it. In this way it is said to have been conveyed by Antipater,¹ through his son Iollas, to the province where Alexander was, and the king was killed by Antipater² with this water.

17. There is a spring in the Alps in the kingdom of Cottius,³ and those who taste of it, at once fall dead. On the Via Campana in the Falerian district in the neighbourhood of Cornetum there is a spring in a grove; everywhere the skeletons of birds, lizards and other snakes are seen lying.

There are also some acid springs, as in Lyncestis,⁴ and in Italy⁵ at Velia, at Teanum in Campania and many other places, which have this property that, when they are drunk, they dissolve the stones which form in the human bladder. 18. This seems to happen by nature, because a sharp and acid juice is present in the soil, and when currents of water pass out of it, they are tintured with acidity. Hence when they enter the body, they disperse what they meet as the water settles and solidifies in the body. We can observe the reason why these are dissolved by acid. If an egg is put in vinegar for some time, the shell will become soft and dissolve. When lead also, which is very pliant and heavy, is placed in a vessel and vinegar is poured in, and the vessel is covered over and sealed, the lead will be dissolved and it will become white lead.⁶

19. In the same way, brass, which is still more

² Aristotle was credited with the scheme, Plin. *N.H.* XXX. 149.

³ Cottius erected the arch of Augustus at Susa W. of Turin, 8 B.C.

⁴ In Macedonia.

⁵ Plin. *N.H.* XXXI. 9.

⁶ Book VII. xii. 1.

natura, similiter curatum si fuerit, dissipabitur et fiet aerugo. Item margarita. Non minus saxa silicea, quae neque ferrum neque ignis potest per se dissolvere, cum ab igni sunt percalefacta, aceto sparso dissiliunt et dissolvuntur. Ergo cum has res ante oculos ita fieri videamus, ratiocinemur isdem rationibus ex acidis propter acritudinem suci etiam calculosos e natura rerum similiter posse curari.

- 20 Sunt autem etiam fontes uti vino mixti, quemadmodum est unus Paphlagoniae, ex quo eam sine vino potantes fiunt temulenti. Aequiculis autem in Italia et in Alpibus natione Medullorum est genus aquae, quam qui bibunt, efficiuntur turgidis gutturibus. 21 Arcadia vero civitas est non ignota Clitor,¹ in cuius agris est spelunca profluens aqua, e qua qui² biberint, fiunt abstemii. Ad eum autem fontem epigramma est in lapide inscriptum: haec sententiae versibus graecis: eam non esse idoneam ad lavandum, sed etiam inimicam vitibus, quod apud eum fontem Melampus sacrificiis purgavisset rabiem Proeti filiarum restituissetque earum virginum mentes in pristinam sanitatem. Epigramma autem est id, quod est subscriptum:

ἀγρότα,³ cὺν ποίμναις τὸ μεσημβρινὸν ἦν εἰ βαρύνῃ⁴
 δῖψος ἀν' ἐχάτιας Κλείτορος⁵ ἐρχόμενον,

¹ clitori H.

² aquae qui H.

³ Epigrammata quae sequuntur eadem graece extant in Eclogis Florentinis (de mirabilibus) quae sub ficto Sotionis nomine (ex cod. Laur. LVI, I) edidit H. Stephanus. H litterarum formis utitur graecis et latinis mixtis, praecipue c, ut in papyris pro σ. ΑΓΡΑΤΑ H.

⁴ ΗΝΕΘΒΑΡΥΗΝ H.

⁵ ΚΑΙΤΟΡΟΣ H.

solid, if it is treated in like manner, will be dissolved and changed into verdigris. So also pearls; and flints, which neither iron nor fire can dissolve of itself, when they are heated in the fire and sprinkled with acid, fly asunder and are dissolved.¹ Therefore, since we see these processes before our eyes, we shall conclude by the same arguments that persons suffering from stone can be cured naturally in like manner by acids owing to their pungency.

20. There are also springs, as it were, mixed with wine, such as one in Paphlagonia, and persons drinking it without wine become drunk. Among the Aquiculi in Italy and among the tribe of the Medulli in the Alps, there is a kind of water which causes goitre² among those who drink it. 21. In Arcadia there is the city of Clitor, not unknown,³ in the lands of which there is a cave with running water, and those who drink of it become abstemious.⁴ Against the spring there is an inscription engraved on the stone. This is the meaning of the Greek verses: that the water is not fit for washing and is also harmful to vines, because at this spring Melampus with sacrifices cleansed the madness of the daughters of Proetus and restored the minds of the girls to their former sanity. This is the inscription⁵ written below:

Shepherd, if at noon thirst oppress thee as thou
comest with thy flocks to the bounds of Clitor,

¹ Vinegar *acetum* is credited with an exaggerated capacity to dissolve pearls.

² *quis tumidum guttur miratur in Alpibus?* Juv. XIII. 162.

³ Cf. Acts, *non ignotae civitatis*, Vg. XXI. 39; οὐκ ἄσημος Ἑλλήνων πόλις (Athens), Eur. *Ion*, 8.

⁴ Ovid, *Met.* XV. 322.

⁵ *Anth. Pal. App.* IV. 20. These three epigrams are found in ps. Sotion *de mirabilibus*.

τὰς μὲν ἀπὸ κρήνης ἄρκεαι ¹ πόμα καὶ παρὰ νύμφαις
 ὑδρεάειν ἐτίθειον πᾶν τὸν αἰπόλιον
 νάμααι μὴτ' ἐπὶ λουτρὰ βάλλης χροί, μὴ σε καὶ αὔρη ²
 πη(νὴ)νη <τερπνῆς> ἐντὸς ³ ἐόντα μέθης·
 φεῦγε δὲ τὴν πηγὴν μεικάμπελον, ἔνθα Μελάμπους
 λυκάμενος λύσεως ⁴ Προϊτίδας ἀρτεμέας ⁵
 πάντα καθαρμὸν ἔκοψεν ἀπόκρυφον, ⁶ <εὗτ' ἄρ' ἀπ'
 Ἄργους
 οὔρεα τρηχεῖς ἤλυθεν Ἀρκαδίας>.

- 22 Item est in insula Cia ⁷ fons, e quo qui imprudentes biberint, fiunt insipientes, et ibi est epigramma insculptum ea sententia: iucundam eam esse potionem fontis eius, sed qui biberit, saxeos habiturum sensos. ⁸ Sunt autem versus hi:

ἡδέ' ἀπὸ ψυχροῦ πόματος λιβάς, ἃ γ' ἀναβαίνει
 <πηγή, ἀλλὰ νόψ> πέτρος ὁ τήνδε πίων. ⁹

- 23 Susis ¹⁰ autem, in qua civitate est regnum Persarum, fonticulus est, ex quo qui biberint, amittunt dentes. Item in eo est scriptum epigramma, quod significat ¹¹ hanc sententiam: egregiam esse aquam ad lavandum, sed ea si bibatur, excutere e radicibus dentes. Et huius epigrammatis sunt versus graece:

¹ ΚΡΗΝΗΚΑΥΧΑΙ H.

² ΜΟΥΤΡΑΒΑΤΙΤΕΧΡΑΜΗΧΚΑΙΔΥΡΗ H.

³ πη(μη)νη <τερπνης> εντος ps. Sol.: ΠΗΝΗCΤΥC H.

⁴ λυκαμενος λυσεως ps. Sol.: ΛΥCΑΜΕΝΟ|CΑΥCΘΗC H.

⁵ ΠΡΟΙΤΙΑCΑΡΤΕΜΕΙΑC H.

⁶ ΚΛΘΑΡΜΟΝΕΚΟΨΕΝΕΠΑΧΡΥΨΟΝ (hoc verbo finitur epigr. in H, reliqua ex Ecl. Flor. addiderunt edd.).

⁷ chia H (cea Plin.).

⁸ Cf. motos H (X. iii. 9).

⁹ ΗΑΕΛΠΟΨΥΧΡΟΥΠΟΜΑΤΟCΑΙΒΑCΑΝΑΒΑΙΝCΙΠΕΤΡΟCΟΤΗΝΑΕΠΙΩΝ H. ἃ γ' ἀναβαίνει Rouse: ἀναβάλλει cod. Laur. ἀναβαίνει H: πηγή, ἀλλὰ νόψ cod. Laur. (om. H).

BOOK VIII. c. III.

Draw water from this fountain, and, near the water nymphs, give rest to all thy goats.

But cast not water for the bath on thy skin, lest the vapour harm thee when thou art plunged in the joys of wine.

Shun my vine-hating spring; here Melampus restored to sense the daughters of Proetus from their frenzy,¹

He smote the scapegoat deep and out of sight, when from Argos he came to the mountains of wild Arcadia.

22. There is also a spring in the island of Chios,² and those who drink of it unawares become stupid. There is an inscription³ carved there to this effect: that a draught of the spring is pleasant, but anyone who drinks will have fossilised notions. The verses follow.

Sweet is the flow of cooling drink, which rises in a fountain, but he who drinks of it is turned to stone in his mind.

23. At Susa also, which is the capital city of Persia, there is a small spring, and those who drink from it lose their teeth. On it there is written an inscription⁴ which bears this meaning: that the water is good for bathing, but whatever is drunk, shakes out the teeth from their roots. Of this inscription the verses run as follows in Greek.

¹ Paus. VIII. 18. 7.

² Pliny says Ceos, *N.H.* XXXI. 15.

³ *Anth. Pal. App.* III. 94. ⁴ *Anth. Pal. App.* III. 101.

ὑδατα κρανάεντα βλέπεις, ξένε, τῶν ἀπο χειρὶν¹
 λουτρὰ μὲν ἀνθρώποι(ς ἀβλαβῇ ἔστιν ἔχειν)²
 ἣν δὲ λάβης κοίλου βοτανήδεος ἀγλαὸν ὕδωρ³
 <ἄκρα μόνον δολιχοῦ χεῖλεος ἀψάμενος>²
 αὐτῆμαρ πριστῆρες ἐ<πὶ χθονὶ δαιτὸς ὀδόντες>²
 πείπτουσιν, γενύων ὄρφανὰ θέντες ἔδη.⁴

24 Sunt etiam nonnullis locis fontium proprietates, quae procreant qui ibi nascuntur egregiis vocibus ad cantandum, uti Tarso,⁵ Magnesia, aliis eiusmodi regionibus. Etiamque Zama est civitas Afrorum, cuius moenia rex Iuba duplici muro saepsit ibique regiam domum sibi constituit. Ab ea milia passus xx est oppidum Ismuc, cuius agrorum regiones incredibili finitae⁶ sunt terminatione. Cum esset enim Africa parens et nutrix ferarum bestiarum, maxime serpentium, in eius agris oppidi nulla nascitur, et si quando adlata ibi ponatur, statim moritur; neque id solum, sed etiam terra ex his locis si alio translata fuerit, et ibi. Id genus terrae etiam Balearibus dicitur esse. Sed aliam mirabiliorem virtutem ea habet terra, quam ego sic accepi.

25 Gaius Iulius Masinissae filius, cuius erant totius oppidi agrorum possessiones, cum patre⁷ Caesare militavit. Is hospitio meo est usus. Ita cotidiano convictu necesse fuerat de philologia disputare. Interim cum esset inter nos de aquae potestate et

¹ ὙΔΑΤΑ ΚΡΑΝΑΕΝΤΑ ΒΛΕΠΕΙΣ ΞΕΝΤΩΝ ΑΠΟΧΕΙΡΙΝ H.

² om. H.

³ ΛΟΥΤΡΑΜΕΝΑΝΤΡΟΠΟΙΗΝΑΘΜ ΒΗΟΚΟ | ΙΔΟΥΒΟΤΑΝ ΗΛΕΟCΑΤ-ΜΟΝΥΔΩΡ H.

⁴ ΑΥΤΗΜΕΡΠΡΙC | ΤΗΡΕCΕΠΕΙΤΟΥCΙΝΤΕΝΥΩΝΟΡΦΑΝΑΘΕΝΤΕCΕΑΗ H. πείπτουσιν hanc orthographiam ubique in evv. habent codices NT. Vat. et Bezae: cf. μείσαμπελον supra.

⁵ uti tharso H.

⁶ finitae ed: -ti H.

⁷ patres H.

Waters from the rock you see, stranger, from which it is safe for men to take to wash their hands;

But if you take of the fair water of the leafy cave, and touch it but with the tip of your lips,

Forthwith those banquet grinders, your teeth, fall on the ground, and leave empty the sockets in your jaw.

24. There are in some places springs which have the property of causing those who are born there to have fine voices for singing; such as at Tarsus, in Magnesia, and elsewhere. Further, there is in Africa the city of Zama¹ the ramparts of which King Juba² enclosed with a double wall, and built his palace there. Twenty miles away is the town of Ismuc. The area of the lands of this city is marked by an incredible barrier. Africa is the mother and nurse of wild creatures, especially snakes, but they do not grow in the neighbourhood of Zama; and if at any time a snake is brought and put there, it dies on the spot. Not only so, but even if soil is taken from these places elsewhere the same thing happens there. (The soil of the Balearic Isles is said to be of that kind.) It has, however, a still more remarkable quality which I learnt in the following way.

25. Gaius Julius, the son of Masinissa, who held possession of the whole lands of the city, fought on the side of the late emperor. He sometimes stayed with me, and in our daily intercourse we were often driven to talk about scholarship. Once the question arose between us about the potency of water and its

¹ Probably from Varro, Plin. *N.H.* XXXI. 15.

² Juba, the father of the historian, fought against Caesar. *Bell. Afric.* 91.

eius virtutibus sermo, exposuit esse in ea terra eiusmodi fontes, ut, qui ibi procrearentur, voces ad cantandum egregias haberent, ideoque semper transmarinos catlastros emere formonsos¹ et puellas maturas eosque coniungere, ut, qui nascerentur ex his, non solum voce egregia sed etiam forma essent non invenusta.

- 26 Cum haec tanta varietas sit disparibus rebus natura distributa quod humanum corpus est ex aliqua parte terrenum, in eo autem multa genera sunt umorum,² uti sanguinis, lactis, sudoris, urinae, lacrimarum: ergo si in parva particula terreni tanta discrepantia invenitur saporum, non est mirandum, si tam in magnitudine terrae innumerabilis suorum reperientur varietates, per quarum venas aquae³ vis percurrrens tincta pervenit ad fontium egressus, et ita ex eo dispaes variique perficiuntur in propriis generibus fontes propter locorum discrepantiam et regionum qualitates terrarumque dissimiles proprietates.

- 27 Ex his autem rebus sunt nonnulla, quae ego per me perspexi, cetera in libris graecis scripta inveni, quorum scriptorum hi sunt auctores: Theophrastos, Timaeus, Posidonios, Hegesias, Herodotus, Aristides, Metrodorus, qui magna vigilantia et infinito studio locorum proprietates, aquarum virtutes ab inclinatione caelique regionum qualitates ita esse distributas scriptis dedicaverunt. Quorum secutus ingressus in

¹ formonsos *H*: formonsam *Verg. E. i. 5*.

² morum *H*.

³ aquae *rec*: quae *H*.

¹ Book VI. *pref. 2*.

² Of Tauromenium; historian of Sicily, fl. 300 B.C.

³ Of Apamea; philosopher, taught at Rhodes, d. 48 B.C.

virtues. He informed me that, in his country, there were springs such that those who were born in the neighbourhood had fine singing voices, and that they bought from time to time across the sea handsome youths and grown-up girls and mated them so that their children might have fine voices and good looks as well.

26. Since, therefore, such variety is produced by nature among diverse things, in that the human body is in part earthy, and at the same time contains humours of many kinds, blood, milk, sweat, urine, tears; if, therefore, in a small particle of the earthy there is found such a discrepancy of flavours, we need not wonder if in the expanse of earth there shall be found such innumerable varieties of juices. The watery energy passing along their channels is tintured with them when it reaches the outflow of the springs. Thus for this reason springs are rendered disparate and various in their several kinds, because of the divergence of localities and the qualities of regions and the unlike qualities of soils.

27. Of these facts there are some which I have observed myself; others I have found recorded in Greek works of which I name the authors: Theophrastus,¹ Timaeus,² Posidonios,³ Hegesias,⁴ Herodotus,⁵ Aristides,⁶ Metrodorus.⁷ These writers, with close attention and unlimited pains, have declared the properties of localities, the virtues of different waters, and by reference to climate, the distribution of regional qualities. Following in their footsteps, I

¹ Of Magnesia nr. Sipylus; historian, fl. 280 B.C.

² Of Lycia; Athen. 75.

³ Of Miletus; historian, Plin. *N.H.* IV.

⁷ Of Scepsis; historian, d. 70 B.C.

hoc libro perscripsi quae satis esse putavi de aquae varietatibus, quo facilius ex his praescriptionibus eligant homines aquae fontes, quibus ad usum salientes possint ad civitates municipiaque perducere.

- 28 Nulla enim ex omnibus rebus tantas habere videtur ad usum necessitates, quantas aqua, ideo quod omnium animalium natura, si frumenti fructu privata fuerit, arbustivo aut carne aut piscatu aut etiam qualibet ex his reliquis rebus escarum utendo poterit tueri vitam, sine aqua vero nec corpus animalium nec ulla cibi¹ virtus potest nasci nec tueri nec parari. Quare magna diligentia industriaque quaerendi sunt et eligendi fontes ad humanae vitae salubritatem.

IV

- 1 EXPERTIONES autem et probationes eorum sic sunt providendae. Si erunt profluentes et aperti, antequam duci incipiantur, aspiciantur animoque advertantur, qua membratura sint qui circa eos fontes habitant homines; et si erunt corporibus valentibus, coloribus nitidis, cruribus non vitiosis, non lippis oculis, erunt probatissimi. Item si fons novos fossus fuerit, et in vas corinthium sive alterius generis, quod erit ex aere bono, ea aqua sparsa maculam non fecerit, optima est. Itemque in aeneo si ea aqua defervefacta et postea requieta et defusa fuerit, neque in eius aenei fundo harena aut limus invenietur, ea aqua erit
2 item probata. Item si legumina in vas cum ea aqua coiecta ad ignem posita celeriter percocta fuerint,

¹ cui H.

¹ Alloy of gold, silver and copper.

have recorded in this book what I thought enough about the different kinds of water, so that from these instructions springs of water might be chosen from which conduits could be taken for the supply of cantons and towns.

28. For of all things, not one seems to be so necessary for use as water, since the nature of all animals, though it be deprived of the use of corn, can maintain life from shrubs or meat or fish or some other provender. But without water, neither the animal frame nor any virtue of food can originate, be maintained, or provided. Hence great diligence and industry must be used in seeking and choosing springs to serve the health of man.

CHAPTER IV

ON TESTING WATER

1. THE discovery and testing of springs is to be pursued in the following manner. When they are abundant and in the open, we are to observe and consider, before we begin to lay the water on, what is the physique of those who live in the neighbourhood. If they are strong, of clear complexion, free from distortion and from inflamed eyes, the water will pass. Again, if a fresh spring be dug, and the water, being sprinkled over a vessel of Corinthian,¹ or any other good bronze, leave no trace, the water is very good. Or if water is boiled in a copper vessel and is allowed to stand and then poured off, it will also pass the test, if no sand or mud is found in the bottom of the copper vessel. 2. Again, if vegetables being put in the vessel with water and boiled, are soon

indicabunt aquam esse bonam et salubrem. Non etiam minus ipsa aqua, quae erit in fonte, si fuerit limpida et perlucida, quoque pervenerit aut profluxerit,¹ muscus non nascetur neque iuncus,² neque inquinatus ab aliquo inquinamento is locus³ fuerit, sed puram habuerit speciem, innuitur⁴ his signis esse tenuis et in summa salubritate.

V

- 1 Nunc de perductionibus ad habitationes moeniaque, ut fieri oporteat, explicabo. Cuius ratio est prima perlibratio. Libratur autem dioptris⁵ aut libris aquariis aut chorobate, sed diligentius efficitur per chorobaten, quod dioptrae libraeque fallunt. Chorobates autem est regula longa circiter pedum viginti. Ea habet ancones in capitibus extremis aequali modo perfectos inque regulae capitibus ad normam coagmentatos,⁶ et inter regulam et ancones a cardinibus compacta⁷ transversaria, quae habent lineas ad perpendicularum recte descriptas pendentiaque ex regula perpendiculara in singulis partibus singula, quae, cum regula est conlocata, ea quae tangent⁸ aequae ac pariter lineas descriptionis, indicant libratam conlocationem.
- 2 Sin autem ventus interpellaverit et motionibus lineae non potuerint certam significationem facere, tunc habeat in superiore parte canalem longum pedes v, latum digitum, altum sesquidigitum, eoque aqua infundatur, et si aequaliter aqua canalisis summa labra⁹

¹ limpida — profluxerit *bis* ponit *H.*

² iuncus *ed*: iuncum *H.* ³ his locus *H.*

⁴ innuitur *e₂ ed.*: innuitur *H.* ⁵ diobtris *H.*

⁶ coagmentatus *H.* ⁷ compactat *H.*

⁸ tangent *ed*: tangentur *H.* ⁹ labra *rec*: libra *H.*

cooked, they will show that the water is good and wholesome. Likewise, if the water itself in the spring is limpid and transparent and if wherever it comes or passes, neither moss nor reeds grow nor is the place defiled by any filth, but maintains a clear appearance, the water is indicated by these signs to be light and most wholesome.

CHAPTER V

ON THE METHOD OF LEVELLING

1. I WILL now explain the supply of water to country houses and to towns. The first stage is to fix levels. This is done by dioptrae, or water levels, or the chorobates.¹ But the more accurate method is by the chorobates because the dioptrae and the water levels mislead. The chorobates is a straight plank about twenty feet long. At the extreme ends it has legs made to correspond, and fastened at right angles to the ends of the plank, and, between the plank and the legs, cross-pieces joined by tenons. These have lines accurately drawn to a perpendicular, and plummets hanging severally over the lines from the plank. When the plank is in position, the perpendiculars which touch equally and of like measure the lines marked, indicate the level position of the instrument.

2. But if the wind disturbs and, owing to their movements, the lines cannot give a certain indication, a channel is to be put on the top side of the plank, five feet long, an inch wide and an inch and a half deep. Let water be poured in. If the water evenly touches the lips of the channel, we shall know that

¹ Neuburger, *op. cit.* gives a drawing, 394.

tanget, scietur esse libratum. Ita eo chorobate cum perlibratum ita fuerit, scietur, quantum habuerit fastigii.

- 3 Fortasse, qui Archimedis libros legit, dicet non posse fieri veram ex aqua librationem, quod ei placet aquam non esse libratam, sed sphaeroides¹ habere schema sed ibi habere centrum, quo loci habet orbis terrarum. Hoc autem, sive plana est aqua seu sphaeroides, necesse est: <ad>² extrema capita regulae sit³ pariter sustinere regulam aquam; sin autem proclinetum erit ex una parte, quae erit altior, non habuerit regulae canal⁴ in summis labris aquam. Necesse⁵ est enim, quocumque aqua sit infusa, in medio inflationem curvaturamque habere, sed capita dextra ac sinistra inter se librata esse. Exemplar autem chorobati erit in extremo volumine descriptum. Et si⁶ erit fastigium magnum, facilius erit decursus aquae; sin autem intervalla erunt lacunosa, substructionibus erit succurrendum.

VI

- 1 Ducrus autem aquae fiunt generibus tribus: rivis per canales structiles, aut fistulis plumbeis, seu tubulis fictilibus. Quorum hae sunt rationes. Si canalibus, ut structura fiat quam solidissima, solumque rivi libramenta habeat fastigata ne minus in centenos pedes semipede eaeque⁷ structurae

¹ phaeroides *H.* ² *add. Ro.*

³ regulae sit *Gr*: regula erit *H.*

⁴ canal^{is} *Joc*: canalem *H.* ⁵ nenesse *H.*

⁶ et si *G*: et sic *H.* ⁷ aequae *H.*, eque *G.*

the levelling is successful. Further, when we have levelled with the chorobates, we shall know the amount of the fall.

3. Perhaps the student of the works of Archimedes may say that true levelling cannot be made by means of water, because his theory is that the surface of water is not level, but is that of a sphere of which the centre is that of the earth. But whether the surface of the water is plane or spherical, it is necessary that the extreme ends of the plank should uphold the water evenly. But if there be a fall at one end, the end which is higher will not have water up to the lips of the channel. For while it is necessary that where water is poured along, there should be an inflation and curvature in the middle, it is also necessary that the ends, right and left, should be level one with another. A drawing of the chorobates is furnished at the end of the book. If the fall is considerable, the flow of the water will be made easier. If there are marshy intervals, the assistance of substructures must be sought.

CHAPTER VI

ON AQUEDUCTS, LEADEN AND EARTHEN PIPES

1. THE supply of water ¹ is made by three methods: by conduits along artificial channels, or by lead pipes, or by earthenware tubes. And they are arranged as follows. In the case of channels, the structure must be on a very solid foundation; the bed of the current must be levelled with a fall of not less than 6 inches in 100 feet. The channels are to be arched over to

¹ Neuburger, *op. cit.* 425 ff. describes in detail the water-supply of the Romans.

conformicentur, ut minime sol aquam tangat. Cumque venerit ad moenia, efficiatur castellum et castello coniunctum ad recipiendam aquam triplex inmisarium, conlocenturque in castello tres fistulae aequaliter divisae intra receptacula coniuncta, uti, cum abundaverit ab extremis, in medium receptaculum redundet.

- 2 Ita in medio ponentur fistulae in omnes lacus et salientes, ex altero in balneas vectigal quotannis populo praestent, ex quibus tertio in domus privatas, ne desit in publico; non enim poterint avertere, cum habuerint a capitibus proprias ductiones. Haec autem quare divisa constituerim, hae sunt causae, uti qui privatim ducent in domos vectigalibus tueantur
- 3 per publicanos aquarum ductus. Sin autem medii montes erunt inter moenia et caput fontis, sic erit faciendum, uti specus fodiantur¹ sub terra librenturque ad fastigium, quod supra scriptum est. Et si tofus erit aut saxum, in suo sibi canalis excidatur, sin autem terrenum aut harenosum erit, solum et parietes cum camara² in specu struantur et ita perducatur. Puteique ita sint facti, uti inter duos sit actus.
- 4 Sin autem fistulis plumbeis ducetur, primum castellum ad caput struatur, deinde ad copiam³ aquae lumen fistularum constituatur, eaeque⁴ fistulae castello⁵ conlocentur ad castellum, quod erit in moenibus. Fistulae ne minus longae pedum denum fundantur. Quae si centenariae erunt, pondus habeant in singulas pondo mcc; si octogenariae,

¹ fodientur *H.*

² camera *H.*

³ ad copiam aquae *e₂ ed*: ad copia quae *H.*

⁴ eaeque: aeq; *H.*, eque *G.*

⁵ *abl. sine prep.*

protect the water from the sun. When they come to the city walls, a reservoir is to be made. To this a triple receptacle is to be joined, to receive the water; and three pipes of equal size are to be put in the reservoir, leading to the adjoining receptacles, so that when there is an overflow from the two outer receptacles, it may deliver into the middle receptacle.

2. From the middle receptacle pipes will be taken to all pools and fountains; from the second receptacle to the baths, in order to furnish a public revenue; to avoid a deficiency in the public supply, private houses are to be supplied from the third: for private persons will not be able to draw off the water, since they have their own limited supply from their receptacle. The reason why I have made this division, is in order that those who take private supplies into their houses may contribute by the water rate to the maintenance of the aqueducts. 3. If there are hills between the city and the fountain head, we must proceed as follows. Tunnels are to be dug underground and levelled to the fall already described. If the formation of the earth is of tufa or stone, the channel may be cut in its own bed; but if it is of soil or sand the bed and the walls with the vaulting are to be constructed in the tunnel through which the water is to be brought. Air shafts are to be at the distance of one actus (120 feet) apart.

4. But if the supply is to be by lead pipes, first of all a reservoir is to be built at the fountain head. Then the section of the pipe is to be determined for the supply of water, and the pipes are to be laid from the reservoir to a reservoir in the city. The pipes are to be cast in lengths of not less than 10 feet. If the lead is 100 inches wide, they are to weigh 1200 lbs.

pondo DCCCCLX; si quinquagenariae, pondo DC; quadragenariae pondo CCCCLXXX; tricenariae pondo CCCCLX; vicenariae pondo CCXL; quinûm denûm pondo CLXXX; denûm pondo CXX;¹ octonûm pondo C; quinquariae pondo LX. E latitudine autem lamnarum, quot digitos habuerint, antequam in rotundationem flectantur, magnitudinum ita nomina concipiunt fistulae. Namque quae lamna fuerit digitorum quinquaginta, cum fistula perficietur ex ea lamna, vocabitur quinquagenaria similiterque reliqua.

5 Ea autem ductio, quae per fistulas plumbeas est futura, hanc habebit expeditionem. Quodsi caput habeat libramenta ad moenia montesque medii non fuerint altiores, ut possint interpellare, sed intervalla, necesse est substruere ad libramenta, quemadmodum in rivis et canalibus. Sin autem non longa erit circumitio, circumductionibus, sin autem valles erunt perpetuae, in declinato loco cursus dirigentur. Cum venerint ad imum, non alte substruitur, ut sit libratum quam longissimum; hoc autem erit venter, quod Graeci appellant *coelian*. Deinde cum venerit adversus clivum, ex longo spatio ventris leniter tumescit; exprimatur in altitudinem summi clivi.²

6 Quodsi non venter in vallibus factus fuerit nec substructum ad libram factum, sed geniculus erit, erumpet et dissolvit fistularum commissuras.³ Etiam in ventre colluviaria⁴ sunt facienda, per quae vis spiritus relaxetur. Ita per fistulas plumbeas aquam qui ducent, his rationibus bellissime poterunt efficere,

¹ CXX G: CCXX H. ² clevis H.

³ commissuras rec: commixturas H.

⁴ colluviaria e, ed: colluviaria H.

¹ The reservoirs or water-towers are represented by the Roman 'Fountains.'

each; if 80 inches, 960 lbs.; if 50 inches, 600 lbs.; if 40 inches, 480 lbs.; if 30 inches, 360 lbs.; if 20 inches, 240 lbs.; if 15 inches, 180 lbs.; if 10 inches, 120 lbs.; if 8 inches, 100 lbs.; if 5 inches, 60 lbs.¹ The pipes receive the names of the sizes from the width of the sheets of lead in inches, before they are bent round into pipes. For when a pipe is made of a sheet of lead 50 inches wide, it is called a fifty-inch pipe, and similarly the rest.²

5. When, however, an aqueduct is made with lead pipes it is to have the following arrangement. If from the fountain head there is a fall to the city, and the intervening hills are not so high as to interrupt the supply, and if there are valleys, we must build up the pipes to a level as in the case of open channels. If the way round the hills is not long, a circuit is to be used; if the valleys are wide-spreading, the course will be down the hill, and when it reaches the bottom, it is carried on a low substructure so that it may be levelled as far as possible. This will form a U-shaped bend which the Greeks call *koilia*. When the bend comes uphill after a gentle swelling spread over the long space of the bend, the water is to be forced to the height of the top of the hill.

6. But if the bend is not made use of in the valleys, or if the pipe is not brought up to a level, and there is an elbow,³ the water will burst through and break the joints of the pipes. Further, stand-pipes are to be made in the bend, by which the force of the air may be relaxed. In this way the supply of water by lead pipes may be carried out in the best manner, because

¹ Plin. *N.H.* XXXI. 58 seems to quote this passage.

² Where two pipes meet at an angle.

quod et decursus et circumductiones et ventres et expressus¹ hac ratione possunt fieri, cum habebunt a capitibus ad moenia ad² fastigii libramenta.

7 Item inter actus ducentos non est inutile castella conlocari, ut, si quando vitium aliqui locus fecerit, non totum onus neque³ opus contundatur et, in quibus locis sit factum, facilius inveniatur; sed ea castella neque in decursu neque in ventris planitia neque in expressionibus neque omnino in vallibus, sed in perpetua aequalitate.

8 Sin autem minore sumptu voluerimus, sic est faciendum. Tubuli crasso corio ne minus duorum digitorum fiant, sed uti hi tubuli ex una parte sint lingulati, ut alius in alium inire convenireque possint. Coagmenta autem eorum calce viva ex oleo subacta sunt inlinienda, et in declinationibus libramenti ventris lapis est ex saxo rubro in ipso geniculo conlocandus isque perterebratus, uti ex decursu tubulus novissimus in lapide coagmentetur et primus ex librati ventris;⁴ ad eundem modum adversum clivum et novissimus⁵ librati ventris in cavo saxi rubri haereat et primus expressionis ad eundem modum coagmentetur.

9 Ita librata planitia tubulorum ad⁶ decursus et expressionis⁷ non extolletur. Namque vehemens spiritus in aquae ductione solet⁸ nasci, ita ut etiam saxa perrumpat, nisi primum leniter et parce a capite aqua inmittatur et in geniculis aut versuris alligationibus aut pondere saburra contineatur.

¹ expressus *ed*: -sis *H*.

² adfastigii libramenta (ad *acc. Sem.*) *H*.

³ onus neque *e*₂: omneque *H*.

⁴ *gen. Graec.* ? ⁵ novissimus *e*₂ *Joc*: -um *H*.

⁶ ad *Mar*: aut *H*. ⁷ *exp*raessionis *H*.

the descent, the circuit, the bend, the compression of the air, can be thus managed when there is a regular fall from the fountain head to the city.

7. Again, it is not without advantage to put reservoirs at intervals of 200 actus (24,000 feet), so that if a fault arises anywhere, neither the whole load of water nor the whole structure may be disturbed, but it may be more easily found where the fault is. But these reservoirs are to be neither in the descent nor on the level portion of the bend, nor on the rise, nor generally in valleys, but on unbroken level ground.

8. But if we wish to employ a less expensive method, we must proceed as follows. Earthenware pipes are to be made not less than two inches thick, and so tongued that they may enter into and fit one another. The joints are to be coated with quicklime worked up with oil. At the descents to the bend, a block of red stone is to be placed at the actual elbow, and pierced so that the last pipe¹ on the incline, and the first from the level of the bend, may be jointed in the stone. In the same way uphill: the last from the level of the bend, and the first of the ascent, are to be jointed in the same way in the hollow of the red stone.

9. Thus, by adjusting the level of the tubes, the work will not be forced out of its place at the downward inclines and the ascents. For a strong current of air usually arises in the passage of water, so that it even breaks through rocks, unless, to begin with, the water is evenly and sparingly admitted from the fountain head, and controlled at the elbows and turns by bonding joints or a weight of ballast. Every-

¹ *ex librati ventri* can hardly be right.

² *solet e, Sulp : solent H.*

Reliqua omnia uti fistulis plumbeis ita sunt conlocanda. Item cum primo aqua a capite inmittitur, ante favilla inmittetur, uti coagmenta, si qua sunt non satis oblita, favilla oblinantur.¹

- 10 Habent autem tubulorum ductiones ea commoda. Primum in opere quod si quod vitium factum fuerit, quilibet id potest reficere. Etiamque multo salubrior est ex tubulis aqua quam per fistulas, quod per plumbum videtur esse ideo vitiosum,² quod ex eo cerussa nascitur; haec autem dicitur esse nocens corporibus humanis. Ita quod ex eo procreatur, <si>³ id est vitiosum, non est dubium, quin⁴ ipsum quoque non sit salubre.

- 11 Exemplar autem ab artificibus plumbariis possumus accipere, quod palloribus occupatos habent corporis colores. Namque cum fundendo plumbum flatur, vapor ex eo insidens corporis artus et inde⁵ exurens eripit ex membris eorum sanguinis virtutes. Itaque minime fistulis plumbeis aqua duci videtur, si volumus eam habere salubrem. Saporemque meliorem ex tubulis esse cotidianus potest indicare victus, quod omnes, et⁶ structas cum habeant vasorum argenteorum mensas, tamen propter saporis integritatem fictilibus utuntur.

- 12 Sin autem fontes, unde ductiones aquarum, faciamus, necesse est puteos fodere. In puteorum autem fossionibus⁷ non est contemnenda ratio, sed acuminibus sollertiaque magna naturales rerum rationes considerandae, quod habet multa variaque

¹ oblinantur *ed*: -nentur *H*.

² neutrum generale.

³ si *add. Joc* (*post ita*).

⁴ quin *G*: qui in *H*.

⁵ inde *h*: indie *H*.

⁶ et structas *Kr.*: exstructas *H*.

⁷ fossionibus *h*: possessionibus *H*.

thing else is to be fixed as for lead pipes. Further, when the water is first sent from the fountain head, ashes are to be put in first, so that if any joints are not sufficiently coated, they may be grouted with the ashes.

10. Water-supply by earthenware pipes has these advantages. First, if any fault occurs in the work, anybody can repair it. Again, water is much more wholesome from earthenware pipes than from lead pipes. For it seems to be made injurious by lead, because white lead is produced by it; and this is said to be harmful to the human body.¹ Thus if what is produced by anything is injurious, it is not doubtful but that the thing is not wholesome in itself.

11. We can take example by the workers in lead who have complexions affected by pallor. For when, in casting, the lead receives the current of air, the fumes from it occupy the members of the body, and burning them thereupon, rob the limbs of the virtues of the blood. Therefore it seems that water should not be brought in lead pipes if we desire to have it wholesome. Our daily table may show that the flavour from earthenware pipes is better, because everybody, even when they pile up their tables with silver vessels,² for all that, uses earthenware to preserve the flavour of water.

12. But if we are to create fountains from which come the water-supplies, we must dig wells. But in digging wells we must not make light of science. The methods of nature must be considered closely in the light of intelligence and experience, because the

¹ Poisoning from lead pipes occasionally occurs in modern times; Neuburger, *op. cit.* 434.

² A silver table set from the House of Menander at Pompeii, is now in the Naples Museum.

terra in se genera. Est enim uti reliquae res ex quattuor principiis composita. Et primum est ipsa terrena; habetque ex umore aquae fontes; item calores, unde etiam sulphur, alumen, bitumen nascitur; aerisque spiritus inmanes, qui, cum graves per intervenia fistulosa terrae perveniunt ad fossionem puteorum et ibi homines offendunt fodientes, ut naturali vaporis obturant¹ eorum naribus spiritus animales; ita, qui non celerius inde effugiunt, ibi interimuntur.²

- 13 Hoc autem quibus rationibus caveatur, sic erit faciendum. Lucerna accensa demittatur; quae si permanserit ardens, sine periculo descendetur. Sin autem eripietur lumen a vi vaporis, tunc secundum puteum dextra ac sinistra defodiantur aestuaria;³ ita quemadmodum per nares spiritus ex aestu<ariis>⁴ dissipabuntur. Cum haec sic explicata fuerint et ad aquam erit perventum, tunc saepiatur a structura,⁵ nec obturentur venae.⁶

- 14 Sin autem loca dura erunt aut nimium venae penitus fuerint, tunc signinis⁷ operibus ex tectis⁸ aut superioribus locis excipiendae sunt copiae. In signinis autem operibus haec sunt facienda. Uti harena primum purissima asperrimaque paretur, caementum de silice frangatur ne gravius quam librarium, calx quam vehementissima mortario mixta, ita ut quinque partes harenae ad duos respondeant. Eorum fossa ad libramentum altitudinis, quod est

¹ obturant *Joc*: obturante *H*.

² interemuntur *H G*.

³ defodiantur aestuaria *ed*: defodianturq aestuaria *H S*.

⁴ aestuariis *Joc*: aestu *H*.

⁵ saepiatur a structura *e*₂: saepiaturas structura *H*.

⁶ venae *e*₃ *ed*: venas *H*. ⁷ signinis *G*: signis *H*.

⁸ tectis *Joc*: testis *H*.

soil contains many various elements. For, like other things, it is composed of four principles. First, it is itself earthy; from the liquid, it has springs of water; there are various heats from which sulphur, alum and bitumen arise; and mighty currents of air. When these are heavy and come through the porous intervals of the soil to the wells which are being dug, they affect the excavators, in so far as the nature¹ of the exhalation chokes the animal spirits in their nostrils. Hence those who fail to escape at once, die there.

13. The precautions against this are to be carried out as follows.² Let a lighted lamp³ be lowered. If it remains alight, the descent will be accomplished without danger. If, however, the light is extinguished by the power of the exhalation, then air-shafts⁴ are to be dug right and left adjoining the well. In this way the vapours from the air will be dissipated, as the air is through the nostrils. When this has been arranged and we come to the water, then let it be enclosed by walling without blocking up the veins.

14. But if the locality is stony, or if the veins of water lie too deep, then supplies are to be collected from the roofs or higher ground in cement cisterns. We must proceed thus in making the cement. First let the purest and roughest sand be provided; then rubble is to be made of broken flint, no piece weighing more than a pound; the strongest lime is to be mixed in a trough, five parts of sand to two of lime. The trench is to be rammed down to the level of the depth

¹ *naturali* substantive.

² The more humane treatment of labour under the Empire is noteworthy.

³ Plin. *N.H.* XXXI. 49.

⁴ Palladius, IX. 9, quotes from this passage.

15 futurum, calcetur vectibus ligneis ferratis. Parietibus calcatis, in medio quod erit terrenum, exinaniatur ad libramentum infimum parietum. Hoc exaequato solum calcetur ad crassitudinem, quae constituta fuerit. Ea autem si duplicia aut triplicia facta fuerint, uti percolationibus transmutari possint, multo salubriorem [et suaviorem]¹ aquae usum efficient; limus enim cum habuerit, quo subsidat, limpidior fiet et sine odoribus conservabit saporem. Si non, salem addi necesse erit et extenuari.

Quae potui de aquae virtute et varietate, quasque habeat utilitates quibusque rationibus ducatur et probetur, in hoc volumine posui; de gnomonicis² vero rebus horologiorum rationibus insequenti perscribam.

¹ et suaviorum *EG: om. HS.*

² gnomonicis *HGS.*

desired with wooden rams shod with iron. 15. After shaping the walls, the soil in the middle is to be emptied to the lowest level of the walls; when this is made even, the bottom is to be covered to the thickness which has been determined. If the cisterns are double or treble, so that they can be changed by percolation, they will make the supply of water much more wholesome. For when the sediment has a place to settle in, the water will be more limpid and will keep a flavour unaccompanied by smell. If not, salt must be added to purify it.

I have laid down in this volume what I could about the virtues and varieties of water, its uses, and how it is supplied and tested; in the next book I will deal with the making of dials and the theory of time-pieces.

BOOK IX

LIBER NONUS

- 1 NOBILIBUS athleticis, qui Olympia, Isthmia, Nemea vicissent, Graecorum maiores ita magnos honores constituerunt, uti non modo in conventustantes cum palma et corona ferant¹ laudes, sed etiam, cum revertantur in suas civitates cum victoria, triumphantes quadrigis in moenia et in patrias invehantur e reque publica perpetua vita constitutis vectigalibus fruantur. Cum ergo id animadvertam, admiror, quid ita non scribtoribus eidem honores etiamque maiores sint tributi, qui infinitas utilitates aevo perpetuo omnibus gentibus praestant. Id enim magis erat institui dignum, quod athletae² sua corpora exercitationibus efficiunt fortiora, scriptores non solum suos sensus, sed etiam omnium, <cum>³ libris ad discendum et animos exacuendos praeparant praecepta.
- 2 Quid enim Milo Crotoniates, quod fuit invictus, prodest hominibus aut ceteri, qui eo genere fuerunt victores, nisi quod, dum vixerunt ipsi, inter suos⁴ cives habuerunt nobilitatem. Pythagorae vero praecepta, Democriti, Platonis, Aristotelis ceterorumque sapientium cotidiana perpetuis industriis culta non solum suis civibus, sed etiam omnibus gentibus

¹ ferant *ed*: ferrent *e*, fuerant *H*.

² athla&e *H*, adhle&e *S*. ³ *add. Ro.*

⁴ inter uos *H*.

¹ There is no need with *G* to supply a reference to Delphi.

BOOK IX

PREFACE

1. FAMOUS sportsmen who win victories at Olympia, Corinth and Nemea,¹ have been assigned such great distinctions by the ancestors of the Greeks that they not only receive praise publicly at the games, as they stand with palm and crown, but also when they go back victorious to their own people they ride triumphant with their four-horse chariots into their native cities, and enjoy a pension for life from the State. When I observe this, I am surprised that similar or even greater distinctions are not assigned to those authors who confer infinite benefits on mankind throughout the ages. For this is the more worthy of enactment, in that while sportsmen make their own bodies stronger, authors not only cultivate their own perceptions, but by the information in their books prepare the minds of all to acquire knowledge and thus to stimulate their talents.

2. For in what respect could Milo of Croton advantage mankind because he was unconquered, or others who won victories in the same kind, except that in their lifetime they enjoyed distinction among their fellow-citizens? But the daily teachings of Pythagoras, Democritus, Plato, Aristotle, and other thinkers, elaborated as they were by unbroken application, furnish ever-fresh and flowering² harvests,

² *florida prata*, Lucr. v. 785.

recentes et floridos edunt fructus. E quibus qui a teneris aetatibus doctrinarum abundantia satiantur, optimos habent sapientiae sensus, instituunt civitatibus humanitatis mores, aequa iura, leges, quibus
 3 absentibus nulla potest esse civitas incolumis. Cum ergo tanta munera ab scriptorum prudentia privatim publiceque fuerint hominibus praeparata, non solum arbitror palmas et coronas his tribui oportere, sed etiam decerni triumphos et inter deorum sedes eos dedicandos iudicari.

Eorum autem cogitata utiliter hominibus ad vitam explicandam e pluribus singula paucorum uti exempla ponam, quae recognoscentes necessario his tribui
 4 honores oportere homines confitebuntur. Et primum Platonis e multis ratiocinationibus utilissimis unam, quemadmodum ab eo explicata sit, ponam. Locus aut ager paribus lateribus si erit quadratus eumque oportuerit duplicare, quod opus fuerit genere numeri, quod multiplicationibus non invenitur, eo descriptionibus linearum emendatis reperitur. Est autem eius rei haec demonstratio. Quadratus locus, qui erit longus et latus pedes denos, efficit areae pedes c. Si ergo opus fuerit eum duplicare, pedum cc, item e paribus lateribus facere, quaerendum erit, quam magnum latus eius quadrati fiat, ut ex eo cc pedes duplicationibus areae respondeant. Id autem numero nemo potest invenire. Namque si XIII constituentur, erunt multiplicati pedes cxcvi, si xv, pedes ccxxv.

BOOK IX. PREFACE

not only to their fellow-citizens but also to all mankind. Those who from tender years are satisfied thence with abundance of knowledge, acquire the best habits of thought, institute civilised manners, equal rights, laws without which no state can be secure. 3. Since, therefore, such boons have been conferred on individuals and communities by wise writers, not only do I think that palms and crowns should be awarded to them, but that triumphs also should be decreed and that they should be canonised in the mansions of the gods.

I will propose, as examples taken from a great number, several conceptions of a few thinkers which have helped the furnishing of human life, in order that the consideration of these may lead mankind to confess that honours should be conferred upon their inventors. 4. And first, out of the many and most useful theorems of Plato,¹ I will set out one with its demonstration. If there is a square area, or field with equal sides, and it is necessary to double it, there will be required some number which cannot be found by multiplication; this is determined by a perfect geometrical figure. Here is the demonstration. A square space which is ten feet long and wide makes 100 feet. If then it is necessary that it should be made double—of 200 feet—and also to make it of equal sides, we must inquire how long the side of that square is to be made, so that it may produce 200 feet, corresponding to the doubling of the area. No one can discover this by arithmetic. For if the side be 14 feet, then the multiplication gives 196 feet; if 15, then 225 feet.

¹ The Paris MS. 7227 contains an illustration indented into the text.

- 5 Ergo quoniam id non explicatur numero, in eo quadrato, longo et lato pedes x quod fuerit, linea ab angulo ad angulum diagonios¹ perducatur, uti dividantur duo trigona aequa magnitudine, singula areae pedum quinquagenum, ad eiusque lineae diagonalis longitudinem locus quadratus paribus lateribus describatur. Ita quam magna duo trigona in minore quadrato quinquagenum pedum linea diagonio fuerint designata,² eadem magnitudine et eodem pedum numero quattuor in maiore³ erunt effecta. Hac ratione duplicatio grammicis rationibus ab Platone, uti schema⁴ subscriptum est, explicata est in ima pagina.
- 6 Item Pythagoras normam sine artificis fabricationibus inventam ostendit, et quam magno labore fabri normam facientes vix ad verum perducere possunt, id rationibus et methodis emendatum ex eius praeceptis explicatur. Namque si sumantur regulae tres, e quibus una sit pedes III, altera pedes IIII, tertia⁵ pedes V, eaeque regulae inter se compositae tangant alia aliam suis cacuminibus extremis schema habentes trigoni, deformabunt normam emendatam. Ad eas autem regularum singularum longitudes si singula quadrata paribus lateribus describantur, cum erit trium latus, areae habebit pedes VIII, quod IIII, XVI, quod V erit, XXV.
- 7 Ita quantum areae pedum numerum duo quadrata ex tribus pedibus longitudinis⁶ laterum et quattuor efficiunt, aequae tantum numerum reddidit unum ex quinque descriptum. Id Pythagoras cum invenisset,

¹ diagonios *Joc* : diagonis *H.*

² designata *ed* : -tae *H.*

³ quattuori | maiore *H.*

⁴ scema *H.*

⁵ tertia : terua *H.*

⁶ longitudes *H.*

5. Since arithmetic does not furnish a solution, let a diagonal line be drawn from angle to angle in the square which was 10 feet long and wide, so that two triangles of equal magnitude, each of the area of 50 feet, are described. On the length of the diagonal let a square be described with equal sides. Therefore two triangles of 50 feet in area will be drawn upon the diagonal line in the lesser square; four triangles of the same magnitude and the same number of feet will be described in the larger square. In this manner the duplication is demonstrated geometrically by Plato in accordance with the figure subjoined at the bottom of the page.¹

6. Again, Pythagoras² demonstrated how to make a set-square without the help of a craftsman. And whereas the craftsman with great labour making a set-square can scarcely carry it out accurately, the exact process is explained in accordance with Pythagoras' instructions. For if three straight rods be taken, of which one is 3 feet long, the second 4 feet, the third 5 feet, and let these rods, being jointed together, touch one another at their extremities in the form of a triangle, they will make a perfect set-square.³ Moreover, if single squares with equal sides be described along the several rods, when the side is 3 feet, it will have 9 feet in area; the 4 feet side, 16; the 5 feet side, 25.

7. Thus the square which is described on 5 feet contains an area measured in feet equal to the area produced by the two squares, one with a side of 3 feet, and one with a side of 4. When Pythagoras

¹ Vitruvius paraphrases Plato, *Meno*, 82 ff.

² Pythagoras himself has left no writings; we do not know what belonged to him as distinguished from his school.

³ This proportion was known empirically to the Egyptians.

non dubitans a Musis se in¹ ea inventione monitum, maximas gratias agens hostias dicitur his immolavisse. Ea autem ratio, quemadmodum in multis rebus et mensuris est utilis, etiam in aedificiis scalarum aedificationibus, uti temperatas habeant graduum librationis, est expedita.

8 Si enim altitudo contignationis ab summa coaxatione² ad imum libramentum divisa fuerit in partes tres, erit earum quinque in scalis scaporum iusta longitudine inclinatio. Quam magnae fuerint inter contignationem et imum libramentum altitudinis partes tres, quattuor a perpendicularo recedant et ibi conlocentur inferiores³ calces scaporum. Ita sic erunt temperatae; et graduum ipsarum scalarum erunt conlocationes. Item eius rei erit subscripta forma.

9 Archimedis vero cum multa miranda inventa et varia fuerint, ex omnibus etiam infinita sollertia id, quod exponam, videtur esse expressum. Nimium Hiero enim Syracusis auctus regia potestate, rebus bene gestis cum auream coronam votivam diis immortalibus in quodam fano constituisset ponendam, manupretio locavit faciendam et aurum ad sacomam adpendit redemptori. Is ad tempus opus manu factum subtiliter regi adprobavit et ad sacomam
10 pondus coronae visus est praestitisse. Posteaquam indicium est factum dempto auro tantundem argenti in id coronarium opus admixtum esse, indignatus Hiero se contemptum esse neque inveniens, qua

¹ amusise in *H.* ² coaxatione *S G*: coaxitione *H G*.

³ inferiores *Gal*: interiores *H*.

¹ Vitruvius himself regarded scientific discoveries as inspired.

² Archimedes thus founded hydrostatics; Mach, *Science of Mechanics*, tr. 86.

³ Hiero II, 270-216 B.C.

discovered this, in the belief that the Muses had advised¹ him in the discovery, he is said to have thanked them and sacrificed victims to them. The same calculation, as it is useful in many things and measurements, so it applies to buildings in the construction of staircases, for the adjustment of the steps.

8. For if the height of a story from the flooring above to the level below is divided into three parts, five such parts will give the inclined string of the staircase in its exact length. Taking the height between the floor above and the level below as three parts, let four parts be set off from the perpendicular and let the foot of the string be placed there. This will be so adjusted; so also will be the plotting out of the several steps of the staircase itself. The drawing of this, also, is subjoined.

9. Archimedes made many and various wonderful discoveries. Of all these the one which I will explain² seems to be worked out with infinite skill. Hiero³ was greatly exalted in the regal power at Syracuse, and after his victories he determined to set up in a certain temple a crown vowed to the immortal gods. He let out the execution as far as the craftsman's wages⁴ were concerned, and weighed the gold out to the contractor to an exact amount.⁵ At the appointed time the man presented the work finely wrought for the king's acceptance, and appeared to have furnished the weight of the crown to scale.

10. However, information was laid that gold had been withdrawn, and that the same amount of silver had been added in the making of the crown. Hiero was indignant that he had been made light of, and

⁴ Plin. *N.H.* XXXIV. 37.

⁵ There was a guild of *sacomarii* makers of weights at Rome.

ratione id furtum reprehenderet, rogavit Archimeden, uti in se sumeret sibi de eo cogitationem. Tunc is,¹ cum haberet eius rei curam, casu venit in balineum, ibique cum in solium descenderet, animadvertit, quantum corporis² sui in eo insideret, tantum aquae extra solium effluere. Itaque cum eius rei rationem explicationis ostendisset, non est moratus, sed exiit gaudio motus de solio et nudus vadens domum verius significabat clara voce invenisse, quod quaereret; nam currens identidem graece clamabat *εὕρηκα εὕρηκα*.

11 Tum vero ex eo inventionis ingressu duas fecisse dicitur massas aequo pondere, quo etiam fuerat corona, unam ex auro et alteram ex argento. Cum ita fecisset, vas amplum ad summa labra³ implevit aquae, in quo dimisit argenteam massam. Cuius quanta magnitudo in vasum depressa est, tantum aquae effluxit. Ita exempta massa quanto minus factum fuerat, refudit sextario mensus,⁴ ut eodem modo, quo prius fuerat, ad labra aequaretur. Ita ex eo invenit, quantum ad certum pondus argenti ad certam aquae mensuram responderet.

12 Cum id expertus esset, tum auream massam similiter pleno vaso demisit et ea exempta, eadem ratione mensura addita invenit ex aquae numero non tantum esse:⁵ minore quanto minus magno corpore eodem pondere auri massa esset quam argenti. Postea vero repleto vaso in eadem aqua ipsa corona demissa

¹ is *S*: his *H*. ² in *del. ed*: incorporis *H*.

³ libra *H*. ⁴ mensus *Joc*: mensus est *H*.

⁵ non tantum esse *Gr*: non tantum se *H*.

failing to find a method by which he might detect the theft, asked Archimedes to undertake the investigation. While Archimedes was considering the matter, he happened to go to the baths. When he went down into the bathing pool he observed that the amount of water which flowed outside the pool was equal to the amount of his body that was immersed. Since this fact indicated the method of explaining the case, he did not linger, but moved with delight he leapt out of the pool, and going home naked, cried aloud that he had found exactly what he was seeking. For as he ran he shouted in Greek: *heuréka heuréka*.¹

11. Then, following up his discovery, he is said to have taken two masses of the same weight as the crown, one of gold and the other of silver. When he had done this, he filled a large vessel to the brim with water, into which he dropped the mass of silver. The amount of this when let down into the water corresponded to the overflow of water. So he removed the metal and filled in by measure the amount by which the water was diminished, so that it was level with the brim as before. In this way he discovered what weight of silver corresponded to a given measure of water.

12. After this experiment he then dropped a mass of gold in like manner into the full vessel and removed it. Again he added water by measure, and discovered that there was not so much water; and this corresponded to the lessened quantity of the same weight of gold compared with the same weight of silver. He then let down the crown itself into the vase after filling the vase with water,

¹ 'I have found.'

invenit plus aquae defluxisse in coronam quam in auream eodem pondere massam, et ita ex eo, quod fuerit plus aquae in corona quam in massa, ratiocinatus reprehendit argenti in auro mittionem¹ et manifestum furtum redemptoris.

- 13 Transferatur mens ad Archytæ Tarentini et Eratosthenis Cyrenæi cogitata; hi enim multa et grata a mathematicis rebus hominibus invenerunt. Itaque cum in ceteris inventionibus fuerint grati, in eius rei concitationibus maxime sunt suspecti. Alius enim alia ratione explicaverunt,² quod Delo imperaverat³ responsis Apollo, uti arae eius, quantum haberent pedum quadratorum, id duplicarentur, et ita fore uti,⁴ qui essent in ea insula, tunc religione liberarentur.

- 14 Itaque Archytas cylindrorum descriptionibus, Eratosthenes organica mesolabi ratione idem explicaverunt. Cum hæc sint tam magnis doctrinarum iucunditatibus animadversa et cogamur naturaliter inventionibus singularum rerum considerantes effectus moveri, multas res attendens admiror etiam Democriti de rerum natura volumina et eius com-

¹ mittionem *H*: v.l. mittix pro miscix *Petr.* 46. 5.

² explicaverunt *rec*: explicarentur *H*.

³ impetraverat *H*.

⁴ fore uti *Ro*: forenti *H S*.

¹ The Delian problem, the duplication of the cube is solved by finding two mean proportionals. If $a : x :: x : y$, and $x : y :: y : b$, then $x^2 = ay$ and $y^2 = xb$. Hence $y^4 = x^2b^2 = ayb^2$; or $y^3 = ab^3$. Therefore if $a = 2b$, $y^3 = 2b^3$; and y is

and found that more water flowed into the space left by the crown than into the space left by a mass of gold of the same weight. And so from the fact that there was more water in the case of the crown than in the mass of gold, he calculated and detected the mixture of the silver with the gold, and the fraud of the contractor.

13. Let us turn our attention to the theorems of Archytas of Tarentum, and of Eratosthenes of Cyrene. For they made for mankind many welcome discoveries by means of mathematics. While, therefore, they were made welcome by their other inventions, they were most admired for their mathematical inspirations. For they satisfied, each by his own method, the demand which Apollo had imposed upon Delos:¹ namely, that the number of cubic feet in his altar should be doubled, and that thereby the residents in the island should be freed from a religious scruple.

14. Archytas² solved the problem by a diagram with cylinders; Eratosthenes by means of an instrument the *mesolabium*.³ These theorems are apprehended with the great pleasure which such methods can give. For we are compelled, when we consider the effects of individual causes, to feel a natural emotion in the presence of inventions. After a wide survey, I admire especially Democritus' treatises on the Nature of Things, and in them the commentary in which there is figured the cutting of the side of the cube which shall be twice the cube of which b is the length of the side.

¹ Hippocrates of Chios formulated the problem in the terms of the previous note. Archytas gave a geometrical solution.

² Eratosthenes' mechanical contrivance is illustrated on Plate K.

mentarium, quo scribitur¹ *cheirotometon*;² in quo etiam utebatur anulo signaturam optice³ est expertus.

15 Ergo eorum virorum cogitata non solum ad mores corrigendos, sed etiam ad omnium utilitatem perpetuo sunt praeparata, athletarum autem nobilitates brevi spatio cum suis corporibus senescunt; [itaque neque cum maxime sunt]⁴ florentes neque posteritati hi, quemadmodum sapientium cogitata hominum vitae, prodesse possunt.

16 Cum vero neque moribus neque institutis scriptorum praestantibus tribuantur honores, ipsae autem per se mentes aeris altiora prospicientes memoriarum gradibus ad caelum elatae⁵ aevo immortali⁶ non modo sententias sed etiam figuras eorum posteris cogunt esse notas. Itaque, qui litterarum iucunditatibus instinctas habent mentes, non possunt non in suis pectoribus dedicatum⁷ habere, sicuti deorum, sic Enni poetae simulacrum; Acci autem carminibus qui studiose delectantur, non modo verborum virtutes sed etiam figuram eius videntur secum habere praesentem esse.⁸

¹ quo scribitur *Gr*: quod scribitur *H*.

² ΧΕΙΡΟΤΟΜΗΤΟΝ *H*.

³ signaturam optice *Gr*: signaretur amolcie *H*.

⁴ itaque neque cum maxime sunt *E G*: om. *H S*: interpolationem ineptam quae contentionem senescunt; florentes perdit.

⁵ elatae *Joc*: -ti *H*.

⁶ aevo immortali *E G*: aeuum immortalitati *H*.

⁷ dedicatum *Joc*: -tas *H*. ⁸ locutio usitata apud *Vitr*.

¹ The influence of gem-cutting may perhaps be traced in the atomic philosophy. It is possible that the hardness of the diamond and corundum (with its allies), which is twice the hardness of iron, along with their crystalline shape, suggested the properties ascribed to atoms: the *ordo positura figurae* as Lucretius puts it.

² Democritus' application of his theory of projection to
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gems.¹ With the help of optics,² he investigated the impression of the seal in the ring which he used.

15. So then the imaginations of these men were directed throughout not only to the improvement of conduct, but to the service of mankind. The distinctions of sportsmen soon pass along with their physique, nor in their prime can they advantage posterity, as the devices of thinkers advantage human life.

16. Thus although honour is given neither to the character nor to the excellent principles of authors, yet their minds of themselves look upon the upper air and rise to heaven by the staircase of human remembrance;³ throughout endless time they make not only their ideas but even their portraits familiar to posterity. Hence those whose minds are stirred by the delights of literature cannot but have the image of Ennius, as of a god, in the chapel of their breast. Those who take studious delight in the poems of Accius⁴ seem to keep at their side, not only his mighty words, but his very present portrait.

perspective was probably contained in his *actinographie*, (Ionic for *actinographia*) Diels, *Fragmente der Vorsokratiker*, II. 64. In that case the *cheirotometon* (Plate K) would be an illustration of an expedient comparable to the *mesolabium*, as an invention following upon a theory of causes. The current mistranslation of this passage arose from rendering *scribitur* as 'write.' In technical language it often means 'draw,' as in Cic. *Tusc.* V. 113, *lineam scribere*. Vitruvius' account of geometrical figures drawn on the shore at Rhodes, along with this passage, suggests that Jesus did not 'write,' but 'drew,' *John* viii. 6.

² Vitruvius probably does not go beyond the idea of survival contained in Ennius' *volito vivos per ora virum*, 'I live and fly from lip to lip.'

⁴ Accius, the greatest tragic dramatist of Rome, was born 170 B.C.

- 17 Item plures post nostram memoriam nascentes cum Lucretio videbuntur velut coram de rerum natura disputare, de arte vero rhetorica cum Cicerone, multi posteriorum cum Varrone conferent sermonem de lingua latina, non minus etiam plures philologi cum Graecorum sapientibus multa deliberantes secretos cum his videbuntur habere sermones, et ad summam sapientium scriptorum sententiae corporibus absentibus vetustate florentes cum insunt inter consilia et disputationes, maiores habent, quam praesentium sunt, auctoritates omnes.
- 18 Itaque, Caesar, his auctoribus fretus sensibus eorum adhibitis et consiliis ea volumina conscripsi, et prioribus septem de aedificiis, octavo de aquis, in hoc de gnomonicis rationibus, quemadmodum de radiis solis in mundo sunt per umbras gnomonis inventae quibusque rationibus dilatentur aut contrahantur, explicabo.

I

- 1 EA autem sunt divina mente comparata habentque admirationem magnam considerantibus, quod umbra gnomonis aequinoctialis alia magnitudine est Athenis,

¹ Traces of Lucretius' influence occur in the astronomical references of Vitruvius.

² Cicero, *de Oratore*, I. 62, ascribes the eloquence displayed sometimes by architects, not to their calling, but to the art of rhetoric; cf. Book I. i. 18.

17. Many also, born in time to come, will seem with Lucretius to investigate *The Nature of Things*, as it were, face to face,¹ or with Cicero, *The Art of the Orator*;² many of our posterity will hold converse with Varro³ *On the Latin Language*; not less, also, many scholars deliberating much with the thinkers of Greece, will seem to hold secret converse with them. In a word, the ideas of scientific writers who are absent in the body, old and yet ever new, come to our counsels and investigations; and all have greater weight than if they were present with us.

18. Therefore, your Highness, I have relied on these authors, and bringing their minds and advice to bear, I have composed these volumes, dealing with buildings in the first seven, and with water in the eighth. In the present volume I will expound the methods of Dialling; how they were discovered from the rays of the sun in the universe, by the shadows of the gnomon, and in what proportions these lengthen or diminish.

CHAPTER I

ON THE UNIVERSE AND THE PLANETS

1. It is ordained by the divine spirit⁴ and inspires great wonder⁵ in those who consider it, that the shadow of the gnomon at the equinox is of one magni-

³ Vitruvius drew also upon Varro's *de Re Rustica*; but his references to philosophers came, not from Varro, but from Greek sources.

⁴ *hoc opus immensi constructum corpore mundi . . . vis animae divina regit.* Man. i. 247-9.

⁵ *mundi et astrorum magnificentia*, Book II. i. 2.

alia Alexandriae, alia Romae, non eadem Placentiae ceterisque orbis terrarum locis. Itaque longe aliter distant descriptionis horologiorum locorum mutationibus. Umbrarum enim aequinoctialium magnitudinibus designantur¹ analemmatorum formae, e quibus perficiuntur ad rationem locorum² et umbrae gnomonum³ horarum descriptiones. *Analemma* est ratio conquisita solis cursu et umbrae crescentis ad brumam⁴ observatione inventa, e qua per rationes architectonicas circinique descriptiones est inventus effectus in mundo.

- 2 Mundus autem est omnium naturae rerum conceptio summa caelumque sideribus conformatum.⁵ Id volvitur continenter circum terram atque mare per axis cardines extremos. Namque in his locis naturalis potestas ita architectata⁶ est conlocavitque cardines tamquam centra, unum a terra inmane⁷ in summo mundo ac post ipsas stellas septentrionum, alterum trans contra sub terra in meridianis partibus, ibique circum eos cardines orbiculos circum centra uti in torno perfecit, qui graece *apsides*⁸ nominantur, per quos pervolat sempiterno caelum. Ita media terra cum mari centri loco naturaliter est conlocata.
- 3 His natura dispositis ita, uti septentrionali parte a terra excelsius habeat altitudinem centrum, in meridiana autem parte in inferioribus locis subiectum

¹ designantur *G*: desidesignantur *H*, si designantur *S G*.

² locorum *rec*: longorum *H G S*.

³ gnomoniū *H S*.

⁴ ad brumam *Ro*: abrumae *H*.

⁵ conformatum *G*: -tus *H*.

⁶ architecta *H S* (cf. naturae architectae vis, *Plin. N. H. X.* 196, *Hard.*).

⁷ inmane *Gr*: inmani *H*.

⁸ apsides *Gr*: pasde *H*.

tude at Athens, another at Alexandria, another at Rome, is different at Piacenza and in other parts of the world. Therefore the designs of dials vary widely with change of place. For the length of the shadows at the equinox determines the design of the *analemma*¹ by which the hours are marked in accordance with the locality and the shadow of the gnomon. The analemma is an exact contrivance invented by observing the course of the sun and the lengthening of the shadow towards the winter, by means of which through architectural² calculations and the use of the compass, the action of the sun in the universe is discovered.

2. The universe is the total conception of the whole system, and the firmament with its ordered constellations. It rolls continually round the earth and sea, on the furthest poles³ of its axis. For there the power of nature like an architect, has contrived and placed the poles like centres, one at a vast distance from the earth at the top of the universe and behind the very stars of the Great Bear, and the other opposite, under the earth in the regions of the south; and there has constructed rims of wheels (which the Greeks call *apsides*) round centres as in a lathe, about which the firmament for ever rolls. Thus the middle of the earth and sea is set by nature in the central place.

3. The arrangement of nature is such that on the north the higher centre is exalted above the earth, while in the southern part the centre lying under the lower

¹ Plate L. The analemma is a geometrical figure with the help of which dials are drawn.

² Architecture includes engineering.

³ Lit. 'hinges.'

a terra obscuretur, tunc etiam per medium transversa et inclinata in meridiem circuli delata zona xii signis est conformata. Quae eorum species stellis dispositis xii partibus peraequatis exprimit depictam ab natura figurationem. Itaque lucentia cum mundo reliquisque sideribus ornatu¹ circum terram mareque pervolantia cursus perficiunt ad caeli rotunditatem.

4 Omnia autem visitata et invisitata temporum necessitate sunt constituta. Ex quis sex signa numero supra terram cum caelo pervagantur, cetera sub terram subeuntia ab eius² umbra obscurantur. Sex autem ex his semper supra terram nituntur. Quanta pars enim novissimi signi depressione coacta versatione subiacens³ sub terram occultatur, tantundem eius contraria e conversationis necessitate suppressa rotatione⁴ circumacta trans locis patentibus ex⁵ obscuris egreditur ad lucem; namque vis una et necessitas utrimque simul orientem et occidentem perficit.

5 Ea autem signa cum sint numero xii partesque duodecumas singula possideant mundi versenturque ab oriente ad occidentem continenter, tunc per ea signa contrario cursu luna, stella Mercuri, Veneris, ipse sol itemque Martis et Iovis et Saturni ut per graduum ascensionem⁶ percurrentes alius alia circuitio-
nionis magnitudine ab occidenti ad orientem in mundo pervagantur. Luna die octavo et vicesimo

¹ ornatū *H.* ² ab eis *H G^c.*

³ subiacens *Gr*: subiciens *H (Iren. C.H. II. 28. 3).*

⁴ rotatione *Joc*: notatione *H.*

⁵ ex *Ro*: & *H.*

⁶ ascensione *H.*

¹ The Zodiac: an imaginary belt extending about eight degrees on either side of the ecliptic.

regions is hidden. Then, moreover, along the middle a transverse and oblique belt,¹ sinking towards the south of the equator, is figured with the twelve signs. (This figure of theirs with stars set in order reveals in twelve equal parts the pattern depicted by nature.)² These, as they shine in their array, along with the heavens and the other constellations, roll round the earth and sea and complete their courses with the revolution of the sky.

4. Now all the signs seen or unseen are constituted by the necessity of the seasons. While six of these revolve above the earth along with the sky, the others going under the earth are obscured by its shadow. Six, however, are always placed above the earth. For whatever part of the last sign driven by its revolution passes under the earth and is concealed by its depression, to that extent the contrary sign forced upwards by the necessity of the revolution is carried round in rotation and from darkness comes to light in the visible heavens. For a single power and compulsion controls simultaneously on both sides the rising and the setting.

5. Now while these twelve signs possess each the twelfth part of the firmament, and continually turn from east to west, through these same signs in the opposite direction the stars³ of the moon, Mercury, Venus, the Sun himself and also Mars, Jupiter and Saturn as though they revolved upon a rising staircase of degrees, each with an orbit of its own, wander in the firmament from west to east. The moon runs

¹ Nature as the artificer.

² *stella* in Manilius often = 'planet,' Housman, *ad* Man. i. 15, *adversos stellarum noscere cursus*.

VITRUVIUS

et amplius circiter hora caeli circuitiōnem percurrens, ex quo signo coeperit ire, ad id signum revertendo perficit lunarem mensem.

6 Sol autem signi spatium, quod est duodecima pars mundi, mense vertente vadens transit; ita XII mensibus XII signorum intervalla pervagando cum redit ad id signum, unde coeperit, perficit spatium vertentis anni. Ex eo, quem circulum luna terdecies in XII mensibus percurrit, eum sol eisdem ¹ mensibus semel permetitur. Mercuri autem et Veneris stellae circa solis radios uti per centrum eum ² itineribus coronantes regressus retrorsus et retardatione faciunt, etiam stationibus propter eam circinationem morantur in spatiis signorum.

7 Id autem ita esse maxime cognoscitur ex Veneris stella, quod ea, cum solem sequatur, post occasum eius apparens in caelo clarissimeque lucens vesperrugo vocitatur, aliis autem temporibus eum antecurrens et oriens ante lucem lucifer appellatur. Ex eoque nonnumquam plures dies in signo commorantur, alias celerius ingrediuntur in alterum signum. Itaque quod non aequè peragunt numerum dierum in singulis signis, quantum sunt moratae prius, transiliendo celerioribus itineribus perficiunt [iustum cursum. Ita efficitur,] ³ uti, quod demorentur in nonnullis signis, nihilominus, cum eripiant se ab necessitate morae, celeriter consequantur iustam circuitiōnem.

8 Iter autem in mundo Mercuri stella ita pervolat, uti trecentesimo et sexagensimo die per signorum

¹ cum sole isdem *H*.

² eum *rec*: cum *H*.

³ iustum—efficitur *EG*: *om. H S*: interpolator quid significet vox perficiunt cum uti coniuncta, nescire videtur.

¹ retardatione is doubtful.

through its orbit from the sign in which it began, on the twenty-eighth day and about an hour more, and returning to that sign completes the lunar month.

6. The sun, journeying for a month, passes over the space of a sign which is the twelfth part of the heavens. Thus in twelve months he traverses the distance of twelve signs, and when he returns to the sign from which he started, he completes the space of the revolving year. Hence the sun measures once in twelve months the circle which the moon in the same number of months runs through thirteen times. The planets Mercury and Venus, with their orbits, encircling the sun's rays as on a centre, retreat backwards and delay their course;¹ thus because of their orbit they delay at the nodes² in their course through the signs.

7. This is best seen from the planet Venus, because when it follows the sun it appears in the sky after sunset, and brightly shining is called the Evening Star.³ At other times it precedes the sun, and rising before the dawn is called Lucifer. Hence sometimes they delay several days in a sign, sometimes they enter more quickly into another sign. Therefore because they do not spend uniformly a fixed number of days in the several signs, they make up by quicker movements the amount they previously delayed; so that while they delay in some signs, none the less, when they escape the compulsion of delay, they quickly make up their proper course.

8. The planet Mercury so completes its path in the firmament that, traversing the spaces of the

¹ Where the orbit of the planet intersects the ecliptic, in Greek *σημειον*.

³ *nec matutinis fulget Lucifer horis Hesperos emenso dederat qui lumen Olympos*, Man. i. 177-8.

spatia currens perveniat ad id signum, ex quo priore circulatione coepit facere cursum, et ita peraequatur eius iter, ut circiter tricenos dies in singulis signis habeat numeri rationem.

- 9 Veneris autem, cum est liberata ab inpeditione radiorum solis, xxx diebus percurrit signi spatium. Quo minus quadragenos dies in singulis signis patitur, cum stationem fecerit, restituit eam summam numeri in uno signo morata. Ergo totam¹ circinationem² in caelo quadringentesimo et octogesimo et quinto die permensa³ iterum in id signum, ex quo signo prius iter facere coepit.
- 10 Martis vero circiter sescentesimo octogesimo tertio siderum spatia pervagando pervenit eo, ex quo initium faciendo cursum fecerat ante, et in quibus signis celerius percurrit, cum stationem fecit, explet dierum numeri rationem. Iovis autem placidioribus gradibus scandens contra mundi versationem, circiter cccxlx diebus in singula signa permetitur, et consistit post annum xi et dies cccxiii⁴ et redit in id signum, in quo ante xii annos fuerat. Saturni vero, mensibus undetriginta et amplius paucis diebus pervadens per signi spatium, anno nono et vicensimo et circiter diebus clx, in quo ante tricensimo fuerat anno, in id restituitur, ex eoque, quo minus ab extremo distat mundo, tanto maiorem circinationem rotae percurrando tardior videtur esse.
- 11 Ei autem, qui supra solis iter circinationes peragunt,

¹ ergo totam *G* : ergotam *H*.

² circinationem *Ro* : circitionem *H*.

³ permansa *H*.

signs, it arrives on the three-hundred-and-sixtieth day at that sign, from which in its previous revolution it entered on its course. Its path is so averaged that it spends about thirty days in each sign.

9. The planet Venus, when it is freed from the hindrance of the sun's rays, traverses the space of some signs in thirty days; so far as it suffers an abatement from forty days in the several signs, after traversing a node, it regains that amount lost by delaying in the several signs. Therefore it completes the whole circuit in the firmament on the four-hundred-and-eighty-fifth day, in that sign from which previously it started on its journey.

10. Mars traverses the spaces of the constellations on about the six-hundred-and-eighty-third day, and reaches the place from which it previously made a beginning in making its journey; where it runs more quickly in the signs, it fulfils the proportionate number of days after passing a node. Jupiter, rising by more easy steps against the revolution of the firmament, measures about three hundred and sixty days against each sign, and after eleven years and three hundred and thirteen days it halts and returns to the sign where it had been twelve years before. Saturn, traversing a sign in twenty-nine months and a few days, takes twenty-nine years and about a hundred and sixty days to regain the sign in which it was thirty years before. From the fact that it is less distant from the furthest verge of the firmament, it seems to be more slow in traversing the greater circumference of its orbit.

11. Those planets which traverse their orbit above

maxime cum in trigono fuerint, quod is inierit, tum non progrediuntur, sed regressus facientes morantur, donique cum ¹ idem sol de eo trigono in aliud signum transitionem fecerit. Id autem nonnullis sic fieri placet, quod aiunt solem, cum longius absit abstantia quadam, non lucidis itineribus errantia per ea sidera obscuritatis morationibus inpedire.² Nobis vero id non videtur. Solis enim splendor perspicibilis et patens sine ullis obscurationibus est per omnem mundum, ut etiam nobis appareant, cum facient eae stellae regressus et morationes. Ergo si tantis intervallis nostra species potest id animadvertere, quid ita divinationibus splendoribusque astrorum iudicamus obscuritatis obici posse?

- 12 Ergo potius ea ratio nobis ³ constabit, quod, fervor quemadmodum omnes res evocat et ad se ducit, ut etiam fructus e terra surgentes in altitudinem per calorem videmus, non minus aquae vapores a fontibus ad nubes per arcus excitari, eadem ratione solis impetus vehemens radiis trigoni ⁴ forma porrectis insequentes stellae ad se perducit et ante ⁵ currentes veluti refrenando retinendoque ⁶ non patitur progredi, sed ad se regredi, in alterius trigoni signum esse.

- 13 Fortasse desiderabitur, quid ita sol quinto a se signo potius quam secundo aut tertio, quae sunt propiora,⁷ facit in his fervoribus retentiones. Ergo, quemadmodum id fieri videatur, exponam. Eius

¹ donique cum = donicum, *Munro* (ad *Lucr.* ii. 1116): donique cum *H*.

² inpedire *Schn*: -ri *H*.

³ ratio nobis *H S G*: rationibus *G*.

⁴ radiis trigoni *rec*: adiis trigoni *H*.

⁵ et ante *Joc*: tantae *H*, ante *S*.

⁶ r&enendoq; *H*. ⁷ propiora *H*.

the path of the sun, especially when they are in the trigon¹ which he has entered, do not go forward but retrograde and delay until the same sun has passed from that trigon into another sign. To some, this seems to happen because the sun, they say, being further away at a certain distance, hinders by the delay of darkness the planets wandering in their unilluminated paths. To us it seems otherwise. For the splendour of the sun is perceptible and patent through all the universe without any obscuration, so that these stars appear² to us even when they retrograde or are stationary. Therefore if our vision can perceive it at such great distances, why do we judge that obscurity may be set against the prophetic splendours of the stars?

12. Therefore the consideration rather commends itself to us that, just as heat evokes all things and draws them to itself, as also we see the crops rising on high from the earth because of the heat, and the watery exhalations raised from the springs to the clouds along the rainbow, so in the same way the mighty force of the sun extending its rays in the form of a triangle draws to itself the planets as they follow, and, as it were curbing and restraining those which precede, prevents their onward movement and compels them to return to it and to be in the sign of another trigon.

13. Perhaps it will be asked, why does the sun cause delay by these heats, in the fifth sign away from itself rather than in the second and third? I will therefore explain how this seems to happen.

¹ Group of four signs answering to one side of an equilateral triangle described in the sun's apparent orbit.

² The planets even at night draw their light from the sun.

radii in mundo uti trigoni paribus lateribus¹ formae liniationibus extenduntur. Id autem nec plus nec minus est ad quintum² ab eo signo. Igitur si radii per omnem mundum fusi circinationibus vagarentur neque extentionibus porrecti ad trigoni formam liniarentur, propiora³ flagrant. Id autem etiam Euripides, Graecorum poeta, animadvertisse videtur. Ait enim, quae longius a sole essent, haec vehementius ardere, propiora⁴ vero eum temperata habere. Itaque scribit in fabula Phaethonte⁵ sic:

καίει τὰ πόρρω, τᾷγγυθεν δ' εὐκρατ' ἔχει.⁶

- 14 Si ergo res et ratio et testimonium poetae veteris id ostendit, non puto aliter oportere iudicari, nisi quemadmodum de ea re supra scriptum habemus.

Iovis autem inter Martis et Saturni circinationem⁷ currens maiorem quam Mars, minorem quam Saturnus pervolat cursum. Item reliquae stellae, quo maiore absunt spatio ab extremo caelo proxumamque habent terrae circinationem,⁷ celerius videntur, quod quae-

¹ lateribus *G*: lateribusque *H S G*.

² quintum *Joc*: quintā *H*.

³ propiora *H^c S*: propiora *H*.

⁴ propiora *H*.

⁵ phaetonte *H*.

⁶ ΚΑΙΕΙΤΑΤΠΟΡΡΩΤΑΝΓΥΓΝΑΙΕΙΕΥΧΡΑΤΑΕΧΕΙ *H*: τᾷγγυθεν
Valcken: εὐκρατ' *Joc*.

⁷ circitionem *H*.

¹ The sun is separated from the opposite trigon by the space of a trigon on either side: each side of the equilateral triangle corresponding to a trigon.

² Euripides gave expression in his plays to the philosophical ideas of his time without engaging in purely philosophical writing.

Its rays are spread out in the firmament on the lines of the diagram of a triangle with equal sides. Now each side extends neither more nor less than to the fifth sign, from that in which the sun is.¹ For if the rays spread over the firmament wandered in circular orbits, and in their extension were not directed in the form of a triangle, the nearer regions would be burnt. Euripides,² the Greek poet, seems to have observed this. For he says that what is farther from the sun burns more vehemently, while it keeps what is nearer in a temperate state. And so he writes as follows in the *Phaethon*:³

He burns the distant: what is near he keeps temperate.

14. If then experience, calculation and the testimony of an ancient poet⁴ shows⁵ this, I think we should not judge otherwise than as we have written above on the matter.

Jupiter, traversing its orbit between Mars and Saturn, pursues a course longer than that of Mars, less than Saturn's. The other planets, also, the farther they are from the verge of the firmament, have an orbit nearest the earth and seem to move more swiftly, because each of them, traversing a

¹ Vitruvius, VIII. pref. 1, quoted from the *Chrysippus* a passage almost expressed in philosophic terms. Here the sun is a king with his palace in Ethiopia. The preceding line runs: 'the hot fire of the king rising over the earth.' Grotius according to Schneider was the first to connect these two lines.

⁴ Vitruvius analyses the notion of 'authority' *auctoritas*, which occurs so often in his work, adding 'testimony' to the *res* and *demonstratio* of I. i. 3.

⁵ The singular verb corresponds to the logical unity of the subject.

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cumque earum¹ minorem circinationem peragens saepius subiens praeterit superiorem.

- 15 Quemadmodum, si in rota, qua figuli utuntur, inpositae fuerint septem formicae canalesque totidem in rota facti sint circum centrum in imo ad crescentes ad extremum, in quibus hae cogantur circinationem facere, verseturque rota in alteram partem, necesse erit eas contra rotae versationem nihil minus adversus itinera perficere, et quae proximum centrum habuerit, celerius pervagari, quaeque extremum orbem rotae peragat, etiamsi aequè celeriter ambulet, propter magnitudinem circinationis multo tardius perficere cursum: similiter astra nitentia contra mundi cursum suis itineribus perficiunt circuitum, sed caeli versatione redundationibus referuntur cotidiana temporis circumlatione.

- 16 Esse autem alias stellas temperatas, alias ferventes, etiamque frigidas haec esse causa videtur, quod omnis ignis in superiora loca habet scandentem flammam. Ergo sol aethera, qui est supra se, radiis exurens efficit² candentem, in quibus locis habet cursum Martis stella; itaque fervens ab ardore solis efficitur. Saturni autem, quod est proxima extremo mundo tangit congelatas caeli regiones; vehementer est frigida. Ex eo Iovis, cum inter utriusque circuitiones habet cursum, a refrigeratione caloreque eorum medio convenientes temperatissimosque habere videtur effectus.

¹ earum *ed*: eorum *H*.

² effecit *H*.

¹ The illustration from the movements of ants was used by contemporary mathematicians. Schneider *ad loc.* quotes Cleomedes and Achilles Tatius (not the novelist).

² *Vehementer* with an adjective.

less orbit, more often moves under and passes the planet above it.

15. To illustrate¹ this: let us suppose that on a wheel such as potters use, seven ants are placed, and as many channels are made in the wheel round the centre as the lowest point, increasing in length to the most distant; let the ants be compelled to make a circuit in these channels and let the wheel be turned the other way; in spite of the revolution of the wheel, they will necessarily complete their journeys in the opposite direction. That which has the channel nearest the centre completes its wanderings more quickly; that which traverses the farthest circuit of the wheel, even if it walks as quickly, finishes its course much more slowly on account of the magnitude of the orbit. In like fashion, the planets advancing in a direction opposite to the movement of the firmament complete a circuit along their own paths. Yet in the revolution of the sky they are carried backwards, by the excess of it over their own motion, in the daily circuit of time.

16. The reason why some stars are temperate, others fiery and others cold, seems to be this, that all fire has a flame which rises to higher regions. Therefore the sun scorches with its rays the aether above it and causes it to burn, and the planet Mars has its course in these regions; hence it is made to burn by the heat of the sun. The planet Saturn, however, which is nearest to the verge of the firmament, touches the frozen regions of the sky; it is exceedingly cold.² Hence Jupiter, having its course between the circuits of either, seems to enjoy the most temperate effects of cold and heat, which suit its middle position.

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De zona xii signorum et septem astrorum contrario opere ac cursu, quibus rationibus et numeris trans-eunt e signis in signa, et circuitum eorum, uti a praeceptoribus accepi, exposui; nunc de crescenti lumine lunae deminutioneque, uti traditum est nobis a maioribus, dicam.

II

- 1 BEROSUS, qui ab Chaldaeorum civitate sive natione progressus in Asia etiam disciplinam Chaldaicam¹ patefecit, ita est professus:

Pilam esse ex dimidia parte candentem, reliqua habere caeruleo colore. Cum autem cursum itineris sui peragens subiret sub orbem solis, tunc eam radiis et impetu caloris corripit convertique candentem propter eius proprietatem luminis ad lumen. Cum autem ea vocata ad solis orbem² superiora spectent, tunc inferiorem partem eius, quod candens non sit, propter aeris similitudinem obscuram videri. Cum ad perpendicularum esset ad eius radios, totum lumen ad superiorem speciem retineri, et tunc eam vocari primam.

¹ chaldaicam *H.*

² orbem *Gr*: orbis *H.*

¹ Berosus was a priest of Bel at Babylon, later he settled at Cos, *infra*, c. vi. 2. He dedicated his *Chaldaica* to Antiochus Soter. He invented a form of dial, c. viii. 1.

² Vitruvius' phrase 'city, or rather nation,' corresponds to the fact that the city of Babylon was in ruins beginning from its capture by Darius. Antiochus Soter, however, restored the temple of Bel.

I have explained the belt of the twelve signs, and the contrary operation and course of the seven planets; the causes and numerical relations by which they pass from sign to sign, and their revolutions as I have learned from my masters. I will now speak of the rising light and waning of the moon, as our predecessors have told us.

CHAPTER II

ON THE RISING AND WANING OF THE MOON

1. BEROSUS,¹ who sprang from the Chaldaean city, or rather nation,² expounded the Chaldaean discipline as far as Asia. He taught as follows:

The moon is a globe with one hemisphere luminous³ and the other of a dark blue colour. Now when it traverses the course of its orbit, and comes under the sun's disk, it is attracted by the sun's rays and violent heat, and, because of the property of the sun's light, the shining hemisphere of the moon turns to that light. But while those upper parts which are attracted look towards the sun's sphere, the lower hemisphere of the moon, which does not shine, seems dark because of its resemblance to the air. When the moon is perpendicular to the sun's rays, all its light is held back on its upper face, and it is then called the first moon.

¹ Berosus uses the phrase ἡμιπύρρον σφαῖραν, Stob. *Ecl.* I. 26. 12. From him Lucretius drew the description of the Chaldaean theory, v. 720-728: *versarique potest, globus ut, si forte, pilai dimidia ex parti candenti lumine tinctus, versandoque globum variantis edere formas, etc.*

- 2 Cum praeteriens vadat ad orientis caeli partes, relaxari ab impetu solis extremamque eius partem candentiae oppido quam¹ tenui linea ad terram mittere splendorem, et ita ex eo eam secundam vocari. Cotidiana autem versationis remissione tertiam, quartam in dies numerari. Septimo die, sol sit ad occidentem, [luna autem inter orientem et occidentem]² medias caeli teneat regiones, quod dimidia parte caeli spatio distaret a sole, item dimidiam³ candentiae conversam habere ad terram. Inter solem vero et lunam cum distet totum mundi spatium et lunae orienti⁴ sol trans contra sit⁵ ad occidentem, eam, quo longius arsit, a radiis remissam XIII die plena rota totius orbis mittere splendorem, reliquosque dies decrescentia cotidiana ad perfectionem lunaris mensis versationibus et cursu a sole revocationibus subire sub rotam radiosque eius, et iam mensuras dierum efficere rationes.
- 3 Uti autem Aristarchus⁶ Samius mathematicus vigore magno rationes varietatis⁷ disciplinis de eadem⁸ reliquit,⁹ exponam. Non enim latet lunam suum propriumque non¹⁰ habere lumen, sed esse uti speculum et ab solis impetu recipere splendorem.

¹ quam *ed*: quamquam *H*.

² luna—occidentem *G*: *om. H S. luna facile intellegitur.*

³ dimidiam *E*: -dia *H*.

⁴ orienti *E*: -tis *H G S*.

⁵ sol trans contra sit *Ro*: sol trans cum transit *H*.

⁶ aristarchus *G*: arhistartus *H*.

⁷ varietates *H G*. ⁸ *sc. luna.*

⁹ reliquid *H*. ¹⁰ non *add. Joo.*

¹ Berosus' optical theory of the conflict between the rays from the moon and the more powerful rays of the sun antici-

2. When the moon in its passage moves towards the eastern parts of the sky, it begins to be released from the sun's force, and the extreme edge of its shining hemisphere in a very thin line lets fall its splendour on the earth; and so therefrom it is called the second moon. Owing to the daily retardation of its revolution, the third and fourth moons and so on are numbered. On the seventh day let the sun be towards the west; the moon occupies the middle region of the sky and has half of the shining hemisphere turned upon the earth because it is distant from the sun by a space equal to the half part of the sky. But when the whole space of heaven separates the sun and moon, and the sun is opposed on the west to the rising moon, the moon, burning at a greater distance, is released from the sun's rays,¹ and on the fourteenth day sends forth its splendour with the full disk of its whole orb. During the remaining days there is a daily decrease until the lunar month is complete; the moon as it revolves along its course is recalled under the sun's disk and rays, and now² completes the order of the days of the month.³

3. I will now explain how Aristarchus the mathematician of Samos, by his powerful intelligence, left in his systematic works an explanation of the moon's phases. For it does not escape him that the moon has not its own proper light, and that it is like a mirror and receives its splendour from the sun's pated Young's discovery of the absorption of light by interference.

² *etiam* = *et iam*; cf. *quon-iam*, *nunc iam*.

³ The whole theory of Berosus about the moon is to be read in the light of the phases of the moon as shown in the diagram, Pl. J.

Namque luna de septem astris circulum proximum terrae in cursibus minimum pervagatur. Ita quot¹ mensibus sub rotam solis radiosque uno die, antequam praeterit, latens obscuratur. Cum est cum sole, nova vocatur. Postero autem die, quo numeratur secunda, praeteriens ab sole visitationem facit tenuem extremae rotundationis. Cum triduum recessit ab sole, crescit et plus inluminatur. Cotidie vero discedens cum pervenit ad diem septimum, distans a sole occidente circiter medias caeli regiones, dimidia luce, et eius quae ad solem pars spectat, ea est inluminata.

- 4 Quarto² autem decimo³ die, cum in diametro spatio totius mundi absit ab sole, perficitur plena et oritur, cum sol sit ad occidentem, ideo quod totum spatium mundi distans consistit contra et⁴ impetu solis totius orbis in se recipit⁵ splendorem. Septimo decimo die cum sol oriatur, ea pressa est ad occidentem. Vicensimo et altero die cum sol est exortus, luna tenet circiter caeli medias regiones, et id quod spectat ad solem, id habet lucidum reliquis⁶ obscura. Item cotidie cursum faciendo circiter octavo et vicensimo die subit sub radios solis, et ita menstruas perficit rationes.

Nunc, ut in singulis mensibus sol signa pervadens auge⁷ et minuit dierum et horarum spatia, dicam.

¹ quod *H S.*

² quarta *G.*

³ decima *G.*

⁴ contra et *G*: contrah& *H.*

⁵ recepit *H G S.*

⁶ reliquis *S G*: reliquus *H G.*

⁷ augit *H S.*

¹ *pressa* = 'near'; cf. Fr. *près*.

force. For, of the seven planets, the moon traverses that circle which is nearest the earth and least in its range. Every month, therefore, it is darkened under the disk and rays of the sun, and lies hid for one day before it passes. When it adjoins the sun, it is called the new moon. On the next day, which is counted the second, it passes away from the sun, and gives a slight visibility to the edge of its disk. When it is three days' distance from the sun, it waxes and receives more light. When in its daily departure it comes to the seventh day, being distant from the western sun about half the region of the sky, it has half its light and that part which looks towards the sun is illuminated.

4. On the fourteenth day, when it is distant from the sun by the diameter of the universe, it becomes full, and rises when the sun is in the west, because being distant the whole space of the universe it stands face to face, and by the force of the sun receives into itself the splendour of the sun's whole orb. When the sun rises on the seventeenth day the moon is near ¹ to the west. When the sun is risen on the twenty-second day the moon holds nearly the middle region of the sky; it keeps bright the part which looks towards the sun; in the other parts the moon is darkened. Further, making its journey from day to day, it is absorbed in the rays of the sun about the twenty-eighth day, and thus completes the order of the month.

In the next place I will describe ² how the sun going through the signs, augments and diminishes each month the length of the day and of the hour.

¹ Manilius describes the signs of the zodiac in their order, i. 262-274.

III

1 NAMQUE cum arietis signum iniit et partem octavam pervagatur, perficit aequinoctium vernum. Cum progreditur ad caudam tauri sidusque vergiliarum, e quibus eminet dimidia pars prior tauri, in maius spatium mundi quam dimidium procurrit procedens ad septentrionalem partem. E tauro cum ingreditur in geminos exorientibus vergiliis, magis crescit supra terram et auget¹ spatia dierum. Deinde <e> geminis cum iniit ad cancerum, qui brevissimum tenet caeli spatium, cum pervenit in partem octavam, perficit solstitiale tempus, et peragens pervenit² ad caput et pectus leonis, quod eae partes cancro³ sunt attributae.

2 E pectore autem leonis et finibus cancri solis exitus percurrentes reliquas partes leonis inminuit diei magnitudinem et circinationis⁴ reditque in geminorum aequalem cursum. Tunc vero a leone transiens in virginem progrediensque ad sinum⁵ vestis eius contrahit circinationem⁴ et aequat ad eam, quam taurus habet, cursus⁶ rationem. E virgine autem progrediens per sinum, qui sinus librae partes habet primas, in librae parte viii perficit aequinoctium autumnale;⁷ qui cursus aequat eam circinationem,⁴ quae fuerat in arietis signo.

3 Scorpionem autem cum sol ingressus fuerit occi-

¹ augit *H S.* ² pervenit *Joc*: perveniens *H.*

³ Cf. canceres, *Cato R. R.* 157. 3.

⁴ circinationis-em *S*: circitionis-em *H.*

⁵ signum *H.* ⁶ cursus *G*: cursū *H S.*

⁷ autumnale *S*: autem tale *H.*

¹ pars = μοῖρα = degree.

² aversum taurum. *Man. i.* 264.

CHAPTER III

ON THE SUN'S COURSE THROUGH THE SIGNS

1. WHEN he enters the sign of the Ram and traverses the eighth degree,¹ he makes the vernal equinox. When he goes on to the tail² of the Bull and the constellation of the Pleiades from which the first half of the Bull stands out, the space which he enters is more than half the firmament³ as he moves to the north. When, after the Bull, he enters the Twins at the rising of the Pleiades, he rises higher above the earth and lengthens the day. Thereupon, after the Twins he enters the Crab, a sign which occupies the shortest space of the heavens; coming to the eighth degree, he completes the solstice, and in his progress reaches the head and breast of the Lion, these parts being assigned to the sign of the Crab.

2. Leaving the breast of the Lion and the limits of the Crab and passing through the remaining degrees of the Lion, he diminishes the length of the daylight and of his circuit, and returns to the movement which he had in the Twins. Passing then from the Lion to the Virgin and reaching the lap of her robe, he contracts his circuit and makes the amount of his course equal to that which the Bull holds. Proceeding from the Virgin over her lap which occupies the first degrees of the Balance, at the eighth degree of the Balance he completes the autumnal equinox. This passage equals the circuit which he made in the sign of the Ram.

3. When the sun enters the Scorpion at the setting

¹ *I.e.* his visible journey between sunrise and sunset.

dentibus vergiliis, minuit progrediens meridianas partes longitudes dierum. E scorpione cum percurrento init in sagittarium ad femina eius, contractiorem diurnum pervolat cursum. Cum autem incipit a feminibus sagittarii, quae pars est attributa capricorno, ad partem octavam, brevissimum caeli percurrit spatium. Ex eo a brevitae diurna bruma ac dies brumales appellantur. E capricorno autem transiens in aquarium adauget et aequat¹ sagittarii longitudine diei spatium. Ab aquario cum ingressus est in pisces favonio flante, scorpionis comparat aequalem cursum. Ita sol ea signa circum pervagando certis temporibus auget aut minuit dierum et horarum spatia.

Nunc de ceteris sideribus, quae sunt dextra ac sinistra zonam signorum meridiana septentrionalique parte mundi stellis disposita figurataque, dicam.

IV

- 1 NAMQUE septentrio, quem Graeci nominant *arctum* sive *helicen*, habet post se conlocatum custodem. Non longe conformata est virgo, cuius supra umerum dextrum lucidissima stella nititur, quam nostri providemiatores,² Graeci *protrugeten*³ vocant; candens autem magis spica⁴ eius est colorata. Item alia

¹ et aequat : exaequat *H.*

² providemiatores *Scaliger* : providentiā maiores *H.*

³ προτρύγητην *Scal* : propygethon *H.*

⁴ spica *Phil* : species *H.*

¹ Manilius describes the northern constellations, i. 308-370; the southern, i. 373-406.

of the Pleiades, he diminishes the length of the day on his southward journey. Passing from the Scorpion when he enters the Archer near his thighs, he traverses a still shorter daily course. Beginning from the thighs of the Archer, a part which is assigned to the Goat, at the eighth degree of the Goat he passes through the shortest space of the sky. Hence, from the brevity of the days, the winter (*bruma*) and the days (*brumales*) receive their names. Passing now from the Goat to the Water-carrier, he increases the length of the day, and equals the circuit of the Archer. From the Water-carrier he enters the Fishes when the west wind blows, and makes a circuit equal to that which he made in the Scorpion. In this way the sun travels through the signs at fixed times, and augments or diminishes the lengths of the day and of the hour.

I will next speak of the other constellations¹ which are situated and figured with stars on the right and left of the zodiac both towards the Meridian and to the north.

CHAPTER IV

ON THE NORTHERN CONSTELLATIONS

1. THE Waggon, which the Greeks call the Bear or *Helice*, has the Keeper of the Bear placed behind it. Not far distant is the constellation of the Virgin. Above her right shoulder rests a very bright star which we call the Vintager, the Greeks *Protrugetes*. But *Spica*, a still more brilliant star in that constellation, is coloured.² There is also another

¹ Manilius v. 270, has *spica horrida*. *Spica*, however, is said to be pure white.

contra est stella media genuorum custodis arcti: qui arcturus dicitur est ibi delicatus.

- 2 E regione capitis septentrionis transversus ad pedes geminorum auriga stat in summo cornu tauri—itemque in summo cornu laevo et auriga pedis¹ una tenet parte stellam—et appellantur² aurigae manui³ haedi, capra laevo umero. Tauri quidem et arietis insuper Perseus—dexterioribus subter currens basem vergiliis,⁴ at sinisterioris caput arietis—et manu dextra innitens Cassiepieae simulacro, laeva supra tauri⁵ tenet gorgoneum ad summum caput, subiciensque Andromedae pedibus.
- 3 Item pisces supra Andromedam, et eius ventris et equi sunt⁶ supra spinam aequi, cuius ventris lucidissima stella finit ventrem equi et caput Andromedae. Manus Andromedae dextra supra Cassiopiae simulacrum est constituta, laeva aquilonalem piscem. Item aquarii⁷ supra equi capitis est. Equi ungulae attingunt aquarii genua; Cassiopia media est dedicata. Capricorni supra in altitudinem aquila et delphinus. Secundum eos est sagitta. Ab ea autem volucris,⁸ cuius pinna dextra Cephei manum adtingit et sceptrum, laeva supra Cassiopiae innititur. Sub avis cauda pedes equi sunt subtecti.
- 4 Inde sagittarii, scorpionis, librae insuper serpens

¹ pedis *Mar*: pedes *H*.

² appellantur *H*: appelluntur *Gr*.

³ manui *Ro*: manus *H*.

⁴ vergilias & *H*: vergiliis at *Kr*.

⁵ supra tauri *Ro*: supra aurigā *H*.

⁶ andromedam et eius ventris et equique sunt *H*: que *om. Gr*.

⁷ sc. simulacrum.

⁸ volucris *e*, *ed*: volueris *H*.

¹ Arcturus is yellow.

² Aratus, 167.

star opposite which is between the knees of the Keeper: this is called *Arcturus* and is of a delicate colour.¹

2. Opposite the top of the Waggon, across towards the feet of the Twins, is the Charioteer² standing on the horns of the Bull. Further, on the tip of the left horn the Charioteer also has at his feet a star on one side. Against the hands of the Charioteer, the Kids are stationed.³ *Capra* is on the left shoulder of the Charioteer. Above the Bull and the Ram stands Perseus;⁴ his right foot supporting the Pleiades; on his left, the head of the Ram; with his right hand he rests on the constellation of Cassiopeia; with his left he holds the Gorgon's head above the Bull and lays it at the feet of Andromeda.

3. The Fishes are beyond Andromeda and are level with her belly and the back of the Horse. A very bright star divides the belly of the Horse and the head of Andromeda. The right hand of Andromeda is placed above the constellation of Cassiopeia, and the left upon the Northern Fish.⁵ The constellation of the Water-carrier is against the Horse's head. The Horse's hoofs touch the knees of the Water-carrier. Cassiopeia is in the middle. Rising above Capricorn⁶ are the Eagle and the Dolphin. Next is the Arrow. On it follows the Swan with its right wing touching the hand and sceptre of Cepheus, and its left resting upon Cassiopeia. Under the tail of the Swan the feet of the Horse are concealed.

4. Then following the Archer, the Scorpion and the Balance, comes the Serpent touching the Crown

¹ Aratus, 166.

² *Ibid.*, 246.

⁴ *Ibid.*, 249 ff.

⁶ *Ibid.*, 316.

summo rostro coronam tangit. Ad eum medium ophiuchos in manibus tenet serpentem, laevo pede calcans mediam frontem scorpionis. A parte¹ ophiuchi capitis non longe positum est caput eius, qui dicitur nisus² in genibus. Autem eorum³ faciliores sunt capitum vertex ad cognoscendum, quod non obscuris stellis sunt conformati.

- 5 Pes ingeniculati ad id fulcitur capitis tempus serpentis, cuius arctorum, qui septentriones dicuntur, implicatus. Parve per eos flectitur delphinus; contra volucris⁴ rostrum proposita lyra. Inter umeros eustodis et geniculati corona⁵ est ordinata.⁶ In septentrionali vero circulo duae positae sunt arctoe scapularum dorsis inter se compositae et pectoribus aversae. E quibus minor *cynosura*, maior *helice* a Graecis appellatur. Earumque capita inter se dispi-cientia sunt constituta, caudae capitibus earum ad-versae contra dispositae figurantur; utrarumque⁷ enim superando eminent.

- 6 In summo per caudas earum esse dicitur. Item serpens est porrecta, e qua stella quae dicitur polus⁸ elucet circum caput maioris septentrionis; namque quae est proxume draconem, circum caput eius involvi-tur. Una vero circum cynosurae caput iniecta est fluxu porrectaque proxime eius pedes. Haec autem

¹ a parte *Ro* : partem *H*.

² nisus *Phil* : nesus *H*.

³ eorum autem *Phil* : autem eorum *H*, *soloecismus*, *Quint*.
I. 5. 39.

⁴ volucris *e₂ ed* : volueris *H*.

⁵ corona *e₂ ed* : coronatā (-tam *E*) *H*.

⁶ ordinata *rec* : orinata *H S*.

⁷ utrarumque . . . earum *Heringa* : utrorumque . . .
eorum *H*.

⁸ polus *rec* : post plus *H*.

with the tip of his mouth. The Serpent-holder has the middle of the Serpent in his hands and treads with his left foot the forehead of the Scorpion.¹ The constellation which is called the Kneeler has its head not far from the head of the Serpent-holder. The tops of their heads are the more easily recognised because they are marked by not inconspicuous stars.

5. The foot of the Kneeler² rests on the temple of the Dragon in which that one of the Bears which is called the Waggon is enfolded. The Dolphin moves dimly³ among them; over against the beak of the Swan the Lyre is prominent. Between the shoulders of the Keeper and the Kneeler the Crown is set in array. In the northern circle, the two Bears are placed joined together with their shoulders back to back and their breasts turned away. Of these the less is called in Greek *Cynosura*,⁴ the greater *Helice*.⁵ Their heads look, one up, one down. Their tails are figured in opposite directions set against each other's heads, and are raised so as to project.

6. The highest point in the heavens is said to be between their tails. The Dragon is also spread out, and from this constellation the pole-star, so-called, shines against the head of the Great Bear. For the Bear which is nearest the Dragon has its head bent round. At the same time the Dragon is thrown in its flowing movement round the head of the Little Bear and reaches its feet. And the

¹ Aratus, 85. ² 'The Kneeler' is also called Hercules.

³ *parve*: οὐ μάλα πολλός, Arat. 316.

⁴ Lit. 'dog's tail,' from its shape.

⁵ *Helice* from sweeping round in a 'curve.'

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intorta replicataque capite minoris ad maiorem, circa rostrum et capitis tempus dextrum. Item supra caudam minoris pedes sunt Cephei, ibique ad summum cacumen facientes stellae sunt trigonum paribus lateribus, insuper arietis signum. Septentrionis autem minoris et Cassiopiae simulacri complures sunt stellae confusae.

Quae sunt ad dextram orientis inter zonam signorum et septentrionum sidera in caelo disposita dixi esse; nunc explicabo, quae ad sinistram orientis meridianisque partibus ab natura ¹ sunt distributa.

V

- 1 PRIMUM sub capricorno subiectus piscis austrinus caudam prospiciens ceti.² Ab eo ad sagittarium locus est inanis. Turibulum sub scorpionis³ aculeo. Centauri priores partes proximae sunt librae et scorpioni. Tenet⁴ in manibus simulacrum, id quod bestiam astrorum periti nominaverunt. Ad virginem et leonem et cancerum anguis porrigens agmen stellarum intortus succingit, regione cancri erigens rostrum,⁵ ad leonem medioque corpore sustinens craterem ad manumque virginis caudam subiciens, in qua inest corvos; quae sunt autem supra scapulas, peraeque sunt lucentia.⁶

¹ ob natura H. ² ceti Phil: cephei H.

³ scorpioni Phil: -nem H.

⁴ tenet Barbarus: tenent H.

⁵ rostrum S: nostrum H.

⁶ lucentia H.

¹ The descriptions of Vitruvius are best understood with the help of maps of the constellations: especially in Greek MS. Vat. 1087. Boll, *Sphaera*, Pl. I.

Dragon is twisted and folded back from the head of the Little Bear to the Great Bear about his snout and the right temple of his head. Further, the feet of Cepheus are on the tail of the Little Bear. And there at the highest point are stars which form a triangle with its equal sides above the Ram. But many stars belonging to the Little Bear and to the constellation of Cassiopeia are confused.

The constellations which are to the right of the east between the Zodiac and the Waggon I have described as figured.¹ I will now explain those which are distributed by nature to the left of the east and in the parts south.

CHAPTER V

ON THE SOUTHERN CONSTELLATIONS

1. FIRST, under Capricorn lies the southern Fish looking towards the tail of the Whale. From that to the Archer is a void. The Altar is under the Scorpion's sting. The front part of the Centaur is nearest to the Balance and Scorpion. He holds in his hands a figure which the astronomers have named the Beast.² The Virgin, the Lion and the Crab are girt about with the Serpent,³ which in its twistings stretches through a procession of stars. It raises its snout to the Crab; against the Lion it supports the Cup with its middle; to the hand of the Virgin it raises its tail, on which rests the Crow. The stars above its shoulders are equally luminous.

² The modern constellation of the Wolf.

³ The Hydra, Aratus, 444 ff.

- 2 Ad anguis inferius¹ ventris, sub caudam subiectus est centaurus. Iuxta² cratera et leonem navis est, quae nominatur Argo, cuius prora obscuratur, sed malus et quae sunt circa gubernacula eminentia videntur, ipsaque navicula et puppis per summam caudam cani iungitur.³ Geminos autem minusculus canis sequitur contra anguis caput. Maior item sequitur minorem. Orion vero transversus est subiectus, pressus ungula tauri,⁴ manu laeva tenens, clavam altera ad geminos tollens.
- 3 Apud⁵ eius vero basim canis parvo intervallo insequens leporem. Arieti et piscibus cetus est subiectus, a cuius crista ordinate utrisque piscibus disposita est tenuis fusio stellarum, quae graece vocitantur *harpedonae*.⁶ Magnoque intervallo introrsus pressus serpentium, attingit summam ceti cristam. Esse fuit per speciem stellarum flumen. Profluit initium fontis capiens a laevo pede Orionis. Quae vero ab aquario fundi memoratur aqua, profluit inter piscis austrini caput et caudam ceti.
- 4 Quae figurata conformataque sunt siderum in mundo simulacra, natura divinaque mente designata, ut Democrito physico placuit, exposui, sed tantum ea, quorum ortus et occasus possumus animadvertere et oculis contueri. Namque uti septemtrionis circum axis cardinem versantur non occidunt neque sub

¹ inferius *Mar*: interius *H*. ² iusta *H*.

³ post iungitur *H* habet paginam aversam sine scriptura folii 133; cf. VII. ix. 2.

⁴ tauri *Phil*: centauri *H*. ⁵ apud *Phil*: caput *H*.

⁶ ἁρπεδῶναι *Turnebus*: hermedonae *H*.

¹ Cf. *ἡν εἰναι* Aristot. The river is the Eridanus.

² The description not only follows Aratus but seems to have been written to a diagram based on the *Phaenomena*.

2. At the lower part of the Hydra's belly, under its tail, the Centaur is placed. Against the Cup and the Lion is the ship Argo; the bows are hidden but the mast and the parts about the stern are seen standing out. The Ship and its stern adjoins the Great Dog at the tip of its tail. The Twins are followed by the Little, and the Great, Dog, opposite the head of the Hydra. Orion lies across pressed by the hoof of the Bull, holding it in his left hand and with the right raising his club towards the Twins.

3. Near his feet is the Great Dog following the Hare at a short interval. Under the Ram and the Fishes comes the Whale; from its head there is a sprinkling of stars arranged in a band towards the two Fishes (called in Greek *harpedonae*), and at a great interval a downward weight of the winding stars touches the mane of the Whale. There was to be ¹ a River under the semblance of stars.² It flows forth taking the beginning of its source from the left foot of Orion. The water which is said to be poured by the Water-carrier flows between the head of the Southern Fish and the tail of the Whale.

4. I have expounded in accordance with the principles of Democritus, the natural philosopher, the figures of the constellations ³ which are shaped and formed in the firmament, and planned by nature and the divine spirit; ⁴ but only those constellations whose risings and settings we can observe and see with our eyes. For just as the two Bears turn round the pole, neither setting nor going under the earth,

³ Vitruvius goes back behind Aratus to the astronomical works of Democritus, which are only known to us in fragments; Diels *Vorsokratiker*, II. 390.

⁴ An echo of Lucretius, iii. 15: *ratio tua coepit vociferari | naturam rerum divina mente coorta.*

terram subeunt, sic circa¹ meridianum cardinem, qui est propter inclinationem mundi subiectus terrae, sidera versabunda latentiaque non habent egressus orientis supra terram. Itaque eorum figurationes propter obstantiam terrae non sunt notae. Huius autem rei index est stella Canopi, quae his regionibus est ignota, renuntiant autem negotiatores, qui ad extremas Aegypti regiones proximasque ultimis finibus terrae terminationes fuerunt.

VI

- 1 DE mundi circa terram pervolitantia duodecimque signorum ex² septentrionali meridianaque parte siderum dispositione, ut sit perspectus docui. Namque ex ea mundi versatione et contrario solis per signa cursu gnomonumque³ aequinoctialibus umbris analemmatorum⁴ inveniuntur descriptiones.
- 2 Cetera ex astrologia, quos effectus habeant signa XII, stellae v, sol, luna ad humanam⁵ vitae rationem, Chaldaeorum ratiocinationibus est concedendum, quod propria est eorum genethliologiae⁶ ratio, uti possint ante facta et futura ex ratiocinationibus

¹ si circa *H S.*

² ex *EG*: & *H S.*

³ gnominum *H.*

⁴ analemmatorum *H S G.*

⁵ humanae *S*: -nā *H.*

⁶ genethliologiae *Joc*: gentililogiae *H.*

¹ *versabunda*, rare, Lucr. vi. 581.

² Canopus is quoted as an example of the principle stated in the next sentence. It is visible at Rhodes. Canopus seems

so round the southern pole which, because of the obliquity of the universe, lies under the earth, constellations are turning¹ in concealment without coming forth and rising above the earth. Hence the earth intervenes and prevents the knowledge of their configuration. A proof of this is the star Canopus,² which to us in these regions is unknown. Yet it (*i.e.* the fact of southern constellations) is reported by merchants who have been to the farthest parts of Egypt and the limits nearest to the ultimate bounds of the earth.

CHAPTER VI

ON ASTROLOGY

1. I HAVE described the revolution of the firmament round the earth and the arrangement of the twelve signs and of the constellations to the north and south so as to present them to a clear view. For from that revolution of the firmament and the contrary motion of the sun through the signs and the equinoctial shadows of the gnomons, the diagrams of the analemma are discovered.

2. For the rest, as to astrology, the effects produced on the human course of life by the twelve signs, the five planets, the sun and moon, we must give way to the calculations of the Chaldaean astrologers,³ because the casting of nativities is special to them so that they can explain the past and the future from astronomical calculations. to have served as a substitute for a polar star to the south; cf. Manilius, i. 218.

³ Chaldaean = astrologer; *Babylonica Chaldaeum doctrina . . . astrologorum*: Lucr. vi. 727-728.

astrorum explicare. Eorum autem inventiones reliquerunt, in quae sollertia acuminibusque fuerunt magnis, qui ab ipsa natione Chaldaeorum profluxerunt. Primusque Berosus in insula et civitate Coos cōsedit ibique aperuit disciplinam, post ea studens Antipater iterumque Athenodorus,¹ qui etiam non e nascentia sed ex conceptione genethliologiae² rationes explicatas reliquit.

- 3 De naturalibus autem rebus Thales Milesius, Anaxagoras Clazomenius,³ Pythagoras Samius, Xenophanes⁴ Colophonius, Democritus Abderites rationes, quibus e rebus natura rerum gubernaretur⁵ quemadmodum cumque effectus habeat, excogitatas⁶ reliquerunt. Quorum inventa secuti siderum et occasus tempestatumque significatus⁷ Eudoxus, Eudemos,⁸ Callippus,⁹ Meto,¹⁰ Philippus, Hipparchus, Aratus ceterique ex astrologia paraepgmatorum disciplinis¹¹ invenerunt et eas posteris explicatas reliquerunt. Quorum scientiae sunt hominibus suspi-ciendae, quod tanta cura fuerunt, ut etiam videantur divina mente tempestatum significatus post futuros ante pronuntiare. Quas ob res haec eorum curis studiisque sunt concedenda.

¹ Athenodorus *Ro*: achinapolis *H*.

² genethliologiae *Joc*: gentiliologiae *H*.

³ Clazomenius *Joc*: glagomeus *H*.

⁴ xenophanes *H*.

⁵ gubernaretur *e*, gubernarentur *H*.

⁶ excogitatas *ed*: excogitatus *H*.

⁷ significatus *H S*: significatos *E G*.

⁸ Eudemos *Gr*: eudemmon *H S*, Eudemon *Joc*.

⁹ callistus *H*. ¹⁰ mello *H*: nomina restituit Turnebus.

¹¹ disciplinis *Joc*: disciplinas *H*.

¹ Vitruvius assigns to Berosus the first place in the succession of Greek writers on astrology, but Babylonian writings on astrology went back as far as Hammurabi, 2250 B.C.

Those who have sprung from the Chaldaean nation have handed on their discoveries about matters in which they have approved themselves of great skill and subtlety. And first,¹ Berosus settled in the island of Cos as a citizen and opened a school there. Then Antipater took up the pursuit, and further, Athenodorus, who left a method of casting nativities, not from the time of birth but from that of conception.

3. In natural philosophy, Thales of Miletus, Anaxagoras of Clazomenae, Pythagoras of Samos, Xenophanes of Colophon, Democritus of Abdera left elaborate theories on the causes by which nature was governed, and the manner in which each produced its effects. Eudoxus,² Eudemos,³ Callippus,⁴ Meton,⁵ Philippus,⁶ Hipparchus,⁷ Aratus,⁸ and others followed up their discoveries, and, with the help of astronomical tables,⁹ discovered the indications of the constellations, of their setting, and of the seasons, and handed down the explanations to after times. Their knowledge is to be highly regarded by mankind, because they so applied themselves, that they seem by divine inspiration to declare beforehand the indications of the seasons. Wherefore these topics may be referred to their care and attention.

¹ Of Cnidus; rejected astrology. Aratus versified his *Phaenomena*.

² Mathematician; of Pergamus.

³ Corrected the cycle of Meton.

⁴ Reformed Attic calendar from 432 B.C.

⁵ Of Opus; mathematician, edited Plato's *Laws*.

⁶ Of Nicaea; greatest mathematician of antiquity, c. 150 B.C.; corrected Aratus.

⁷ Of Soli; c. 270 B.C.; wrote the *Phaenomena*.

⁸ *paraepagma* = column with astronomical tables.

VII

- 1 Nobis autem ab his separandae sunt rationes et explicandae menstruae dierum brevitates itemque depalationes. Namque sol aequinoctiali tempore ariete libraque versando, quas e gnomone partes habent novem, eas umbrae facit viii in declinatione caeli, quae est Romae. Idemque Athenis quam magnae sunt gnomonis partes quattuor, umbrae sunt tres, ad vii Rhodo v, ad xi Tarenti ix, ad ¹ quinque <Alexandriae> tres, ceterisque ² omnibus locis ³ aliae alio modo umbrae gnomonum aequinoctiales a natura rerum inveniuntur disparatae.
- 2 Itaque in quibuscumque locis horologia erunt describenda, eo loci sumenda est aequinoctialis umbra, et si erunt quemadmodum Romae gnomonis partes novem, umbrae octo,⁴ describatur ⁵ in planitia et e media *pros orthas* erigatur ut sit ad normam quae dicitur gnomon. Et a linea, quae erit planities in linea gnomonis circino ⁶ novem spatia demetiantur; et quo loco nonae partis ⁷ signum fuerit, centrum constituatur, ubi erit littera A; et deducto circino ab eo centro ad lineam planitiae,⁸ ubi erit littera B, circinatio circuli describatur, quae dicitur meridiana.
- 3 Deinde ex novem partibus, quae sunt a ⁹ planitia ad gnomonis centrum, viii sumantur et signentur in

¹ adquinq, ii. rhodo xv. adtaranti .xi. quinque adtres H: *correzit Joc.*

² coterris H. ³ lonis H. ⁴ octogenae H.

⁵ describatur Joc: -bantur H.

⁶ circino Joc: circini H. ⁷ partes H S.

⁸ ad lineam planities e₃: ablinea planitia H.

⁹ a Joc: in H.

¹ *pros orthas* seems to be the trade term for an upright line.

CHAPTER VII

ON THE PRINCIPLES OF DIALLING

1. WE must separate from other astronomical studies the description of the shortening and marking of the days, month by month, on the dial. For the sun, in his revolution, at the time of the spring and autumn equinoxes, casts a shadow, in the latitude of Rome, which is equal to eight-ninths of the height of the gnomon. Further, at Athens the shadows are three-quarters of the gnomon, at Rhodes five-sevenths, at Tarentum nine-elevenths, at Alexandria three-fifths; and in other places the shadows of the gnomon at the equinox are found to differ by different amounts, in accordance with the Nature of Things.

2. Therefore in whatever places dials are to be set out, the length of the shadow at the equinox is to be taken. If, as at Rome, there are nine parts of the gnomon, and eight parts of the shadow, let a line¹ be drawn on the level, and from the middle let there be set upright and with a set-square, a perpendicular which is called the gnomon; and on the line where the level surface is, let nine parts be measured starting from the foot of the gnomon; where the end of the ninth part is marked, let a centre be taken and indicated by the letter A; and extending the compasses from that centre to a point in the line, to be indicated by the letter B, let the circumference of the circle be described which we call the meridian.² 3. Then of the nine parts which are between the centre of the gnomon and the point on the level line, let eight be taken and indi-

¹ See diagram, Pl. L.

linea, quae¹ est in planitia, ubi erit littera c. Haec autem erit gnomonis aequinoctialis umbra. Et ab eo signo et littera c per centrum, ubi est littera A, linea perducatur, ubi erit solis aequinoctialis radius. Tunc a centro diducto circino ad lineam planitiae aequilatio signetur, ubi erit littera E sinisteriore parte et I dexteriore² in extremis lineis circinationis. Et per centrum perducendum, ut aequa duo hemicyclia sint divisa. Haec autem linea a mathematicis dicitur *horizon*.

- 4 Deinde circinationis totius sumenda pars est xv; et circini centrum conlocandum in linea circinationis, quod loci secat eam lineam aequinoctialis radius, ubi erit littera F; et signandum dextra sinistra, ubi sunt litterae G H. Deinde ab his <et per centrum> lineae³ usque ad lineam planitiae perducendae sunt, ubi erunt litterae T R. Ita erit solis radius unus hibernus, alter aestivus. Contra autem <E>⁴ littera I erit, qua⁵ secat circinationem linea,⁶ quae est traiecta per centrum, ubi erunt⁷ litterae Y K L G, et contra K litterae erunt K H X L; et contra c et F et A
5 erit littera N. Tunc perducendae sunt *diametro*⁸ ab G ad L et ab H <ad K>.⁹ Quae erit superior, partis erit aestivae, inferior hibernae. Eaeque *diametro*¹⁰ sunt aequae mediae dividendae, ubi erunt litterae O et M, ibique centra signanda. Et per ea signa et centrum A¹¹ lineae ad extremas lineae circinationis

¹ qua est H. ² I dexteriore Joc: et inde alteriore H.

³ <et per centrum> lineae Joc: lineis H.

⁴ E add. Joc. ⁵ qua Kr: qui H.

⁶ linea Joc: lineae H.

⁷ litterae I . K . L . M. et contra K lineae erunt K . H . X . I
H: Y K L G . . . K H X L Gr.

⁸ diametro ab .c. ad .i. et ab .h. H: corr. Joc.

⁹ quae erit inferior partis erit aestiv(a)e superior hibernae H (corr. Mar).

cated by a point *c*. This will be the equinoctial shadow of the gnomon. From the point marked *c* let a line be drawn through the centre *a*; and this will represent a ray of the sun at the equinox. Then extending the compasses from *a* let a line be drawn parallel to the level surface, with the letter *e* on the left side and the letter *i* on the right side of the circumference, let them be joined through the centre, so that they divide the circle into two equal semicircles. This line is called the horizon by the mathematicians.

4. Then the circumference is to be divided into fifteen parts, and the centre of the compasses is to be put at that point *r* in the circumference where it is cut by the equinoctial ray *c*, and the points *g* *h* are to be marked right and left. Then from these, through the centre, lines are to be carried through to the line of the plane where the letters *τ* *ρ* are to be put. One line will mark the ray of the sun in winter, the other the ray of the sun in the summer. Over against *e* will be the letter *i* on the horizon which cuts the circumference and passes through the centre. In this quarter are the points *γ* *κ* *λ* *α*. Over against *κ* will be the points *κ* *η* *λ*. And over against *c* *ρ* *a* will be the letter *ν*. 5. Then diameters are to be drawn from *g* to *l* and from *h* to *κ*. The upper will determine the summer portion, and the lower the winter portion. These diameters are to be equally divided in the middle at the letters *ο* and *μ*, and the centres marked. Through those letters and the centre *a*, a line is to be produced to the circumference at the points

¹⁰ æqu(a)e diametro *H*.

¹¹ centrum .c. *H*.

sunt perducendae, ubi erunt litterae q et p;¹ haec erit linea *pros orthas* radio aequinoctiali. Vocabitur autem haec linea mathematicis rationibus *axon*. Et ab eisdem centris deducto circino ad extremas diametros describantur hemicyclia,² quorum unum erit aestivum, alterum hibernum.

6 Deinde in quibus locis secant lineae parallelae³ lineam eam quae dicitur horizon, in dexteriore parte erit littera s,⁴ in sinisteriore v. Et ab littera s ducatur linea parallelus axoni⁵ ad extremum hemicyclium, ubi erit littera v; et ab v⁶ ad sinistram hemicyclii item parallelus linea ducatur⁷ ad litteram x. Haec autem parallelus linea vocitatur *laetotomus*.⁸ Et tum circini centrum conlocandum est eo loci, quo secat circinationem aequinoctialis radius, ubi erit littera d;⁹ et deducendum ad eum locum, quo secat circinationem aestivus radius, ubi est littera n. E centro aequinoctiali intervallo aestivo circinatio circuli menstrui agatur, qui manaeus dicitur. Ita habebitur analemmatos deformatio.

7 Cum hoc ita sit descriptum et explicatum, sive per hibernas lineas sive¹⁰ per aestivas sive per aequinoctiales aut etiam per menstruas in subiunctionibus rationes horarum erunt ex analemmatos¹¹ describendae, subicianturque in eo multae varietates et genera

¹ q et p Gr: G. P. T. R. H.

² icyclia H.

³ parallelae Ro: parallelon & H.

⁴ littera s Joc: littera .e. H.

⁵ axoni Joc: axon H.

⁶ ab v Gr: ab .c. H.

⁷ linea vocitatur Joc: lineae vocitantur H.

⁸ laetotomus Turnebus: locithomus H.

⁹ littera d Mar: littera .e. H.

¹⁰ post lineas sive in H repetuntur aequinoctialis radius — secat circinationem.

q and p. This line will be perpendicular to the equinoctial ray; in mathematical calculations it is called the axis. From m and o as centres, the compasses are extended to the ends of the diameters and semicircles are described, of which one will be for the summer, the other for the winter.

6. Then, at the places where the parallel lines cut the line called the horizon, let the right-hand point be s and the left-hand point be v. From the letter s let there be drawn a line parallel to the axis, to the farther semicircle at the point y; and from v let there be drawn also a parallel line on the left of that semicircle to the letter x. This parallel line is called the *laetomus*.¹ Then the centre of the compasses is to be placed on the point marked d where the equinoctial radius cuts the circumference, and they are to be extended to the point h where the circumference is intersected by the summer radius. From the equinoctial centre with a radius to the summer intersection, let the circle of the months be drawn which is called *Manaeus*. This will complete the design of the analemma.²

7. The analemma in this way has been set forth and explained, whether the figures of the hours are to be marked by the analemma according to the winter lines or the summer lines or the equinoctial or indeed the monthly lines in accordance with the annexed figure. From the analemma there may be deduced many varieties and kinds of dials and they

¹ *laetomus* = cut to the left.

² Vitruvius seems to describe a diagram placed before the reader, but it is not possible to reconstruct with complete certainty the diagram which is lost, from his description.

¹¹ *anallætiōs H.*

horologiorum et describuntur rationibus his artificiosis. Omnium autem figurarum descriptionumque earum effectus unus, uti dies aequinoctialis brumalisque idemque solstitialis in duodecim partes aequaliter sit divisus. Quas ob res non pigritia deterritus praetermissis, sed ne multa scribendo offendam, a quibusque inventa sunt genera descriptionesque horologiorum, exponam. Neque enim nunc nova genera invenire possum nec aliena pro meis praedicanda videntur. Itaque quae nobis tradita sunt et a quibus sint inventa,¹ dicam.

VIII

- 1 HEMICYCLIUM excavatum ex quadrato ad enclimaeque succisum Berosus² Chaldaeus dicitur invenisse; scaphen sive hemisphaerium dicitur Aristarchus Samius, idem etiam discum in planitia; arachnen Eudoxus astrologus, nonnulli dicunt Apollonium; plinthium³ sive lacunar,⁴ quod etiam in circo Flaminio est positum, Scopinas Syracusius; *pros ta historumena*, Parmenion, *pros pan clima*, Theodosius et Andrias, Patrocles pelecinum, Dionysodorus⁵ conum, Apollo-

¹ inventi *H.*

² berossus *H.*

³ plinthium *Joc*: panthium *H.*

⁴ lacunar *G*: lacunas *H S.*

⁵ dioniso porusconum *H*: *corr. Mach.*

¹ Book IX. ii. 3. The following references relate to forms of dials. ² Of Perga. Book I. i. 17. ³ Book I. i. 6.

⁴ Prof. Granger's belief that *panthium* of *H* is right, that the Pantheon of Rome is meant, and that this was a great sundial, is not credible.

are drawn by these technical methods. But of all these figures and drawings, the result is the same: the length of the day at the equinoxes and at the winter and summer solstices is divided into twelve equal parts. Wherefore they have not been omitted because I shrank from the labour involved; but without transgressing by long recitals, I will set forth the kinds and the figures of dials with the names of their inventors. For I cannot now invent new kinds, and the work of other men is not to be put forth as my own. Therefore I will say what has been handed down, and by whom it has been invented.

CHAPTER VIII

ON VARIOUS DIALS AND THEIR INVENTORS

1. BEROSUS the Chaldaean is said to have invented the semicircular dial hollowed out of a square block and cut according to the latitude; Aristarchus¹ of Samos, the Bowl or Hemisphere, as it is said, also the Disk on a level surface; the astronomer Eudoxus, or as some say Apollonius,² the Spider; Scopinas³ of Syracuse, the *Plinthium*⁴ or Ceiling, of which an example is in the Circus Flaminius;⁵ Parmenio, the Dial for Consultation; Theodosius⁶ and Andrias, the Dial for All Latitudes; Patrocles, the Dovetail; Dionysodorus,⁷ the Cone; Apollonius, the Quiver.

¹ Augustus divided the city into fourteen regions. The ninth was known as the Circus Flaminius. Vitruvius refers to a temple of Castor in the same region, Book IV. viii. 4.

² Theodosius of Tripolis in Lydia, wrote on spherical trigonometry, 1st cent. B.C.

⁷ Of Melos, geometer, Strabo, XII. 548.

nus pharetram, aliaque genera et qui supra scripti sunt et alii plures inventa reliquerunt, uti conarachnen,¹ conicum² plinthium, antiboreum. Item ex his generibus viatoria pensilia uti fierent, plures scripta reliquerunt. Ex quorum libris, si qui velit, subiectiones invenire poterit, dummodo sciat analemptos descriptiones.

² Item sunt ex aqua conquisitae ab eisdem scriptoribus horologiorum rationes, primumque a Ctesibio³ Alexandrino, qui etiam spiritus naturalis pneumatikasque⁴ res invenit. Sed uti fuerint ea exquisita, dignum studiosis agnoscere. Ctesibius enim fuerat Alexandriae natus patre tonsore. Is ingenio et industria magna praeter reliquos excellens dictus est artificiosis rebus se delectare. Namque cum voluisset in taberna sui patris speculum ita pendere, ut, cum duceretur susumque reduceretur, linea latens pondus deduceret, ita conlocavit machinationem.

³ Canalem ligneum sub tigno fixit ibique trocleas conlocavit; per canalem lineam in angulum deduxit ibique tubulos struxit; in eos pilam plumbeam per lineam demittendam curavit. Ita pondus cum decurrendo in angustias tubulorum premeret caeli crebritatem, vehementi decursu per fauces frequentiam caeli compressione⁵ solidatam extrudens in aerem patentem offensione tactus⁶ sonitus expresserat claritatem.

¹ conarachnen *Mar*: conarchenen *H*.

² conicum *Ro*: conatum *H*.

³ a Ctesibio *ed. Fl*: achesbio *H*.

⁴ pneumatikasque *ed*: ineū atticasq *H*.

⁵ confressionem *H S*.

⁶ offensionē tactu *H*: offensione tactus *Ro*.

The persons already enumerated and many others left behind them other discoveries, such as the Conical Spider, the Conical Ceiling and the Anti-borean. Many also have left instructions for making Hanging Dials for travellers. From such works anyone who wishes can find instructions, provided he understands the method of describing the analemma.

2. The same writers have also sought the methods of making water-clocks;¹ and first, Ctesibius² of Alexandria, who also discovered the nature of wind-pressure and the principles of pneumatics. It is worth a student's while to learn how these discoveries were made. Now Ctesibius was the son of a barber and was born at Alexandria. He was marked out by his talent and great industry, and had the name of being especially fond of mechanical contrivances. On one occasion he wanted to hang the mirror in his father's shop, in such a way that when it was pulled down and pulled up again, a hidden cord drew down the weight; and he made use of the following expedient.

3. He fixed a wooden channel under a beam of the ceiling, and inserted pulleys there. Along the channel he took the cord into a corner where he fixed upright tubes. In these he had a lead weight let down by the cord. Thus when the weight ran down into the narrow tubes, and compressed the air, the large amount of air was condensed as it ran violently down through the mouth of the tube and was forced into the open; meeting with an obstacle, the air was produced as a clear sound.

¹ Hero Alex. *ed.* Schmidt, I. 491-494. Vitruvius draws upon the same sources as Hero. Heiberg, *Gesch. d. Math.* 73.

² Book I. i. 7.

- 4 Ergo Ctesibius cum animadvertisset ex tractu caeli et expressionibus spiritus vocesque nasci, his principiis usus hydraulicas machinas primus instituit. Item aquarum expressiones automatopoetasque¹ machinas multaue deliciarum genera, in his etiam horologiorum ex aqua conparationes explicuit. Primumque constituit cavum ex auro perfectum aut ex gemma terebrata; ea enim nec teruntur percussu
 5 aquae nec sordes recipiunt, ut obturentur. Namque aequaliter per id cavum influens aqua sublevat scaphium² inversum, quod ab artificibus phellos sive tympanum dicitur. In quo conlocata est regula versatile tympanum.³ Denticulis aequalibus sunt perfecta, qui denticuli alius alium impellentes versationes modicas faciunt et motiones. Item aliae regulae aliaque tympana ad eundem modum dentata una motione coacta versando faciunt effectus varietatesque motionum, in quibus moventur sigilla, vertuntur metae, calculi aut ova proiciuntur, bucinæ canunt, reliquaue parerga.
 6 In his etiam aut in columna aut parastatica horae describuntur, quas⁴ sigillum egrediens ab imo virgula significat in diem totum. Quarum⁵ brevitates aut crescentias cuneorum adiectus aut exemptus in singulis diebus et mensibus perficere cogit. Praeclusiones aquarum ad temperandum ita sunt constitutae. Metae fiunt duae, una solida, una cava, ex

¹ automato pictasque *H S*: corr. *Turnebus*.

² scaphium *Turn*: scaphum *H*. ³ *asyndeton ut saepe*.

⁴ quas *Joc*: quae *H*. ⁵ quarum *Joc*: quorum *H*.

¹ Plate M, based upon Barbaro *Vitruvius*, A.D. 1584, p. 433, illustrates the method of such contrivances.

² The upper part of Plate M exhibits an application to this special case: see Notes on M.

4. Ctesibius, therefore, when he observed that the air being drawn along and forced out gave rise to wind-pressure and vocal sounds, was the first to use these principles and make hydraulic machines. He also described the use of water-power in making automata and many other curiosities, and among them the construction of water-clocks. First he made a hollow tube of gold, or pierced a gem; for these materials are neither worn by the passage of water nor so begrimed that they become clogged. 5. The water flows smoothly through the passage, and raises an inverted bowl which the craftsmen call the cork or drum.¹ The bowl is connected with a bar on which a drum revolves. The drums are wrought with equal teeth, and the teeth fitting into one another cause measured revolutions and movements. Further, other bars, and other drums toothed after the same fashion, and driven together in one motion cause, as they revolve, various kinds of movement; therein figures are moved, pillars are turned, stones or eggs are let fall, trumpets sound, and other side-shows.

6. Among these contrivances also, the hours are marked on a column or pilaster; and these are indicated by a figure² rising from the lowest part and using a pointer throughout the day. The shortening and lengthening of the pointers was brought about through the addition or removal of wedges for each day and each month.³ To regulate the supply of water, stopcocks are thus formed. Two cones are made, one solid, one hollow, and so finished

³ The apparatus required the adjustment of the pointers, and this was done by wedges.

torno ita perfectae, ut alia in aliam inire convenireque possit et eadem regula laxatio earum aut coartatio efficiat aut vehementem aut lenem in ea vasa aquae influentem cursum. Ita his rationibus et machinatione ex aqua componuntur horologiorum ad hibernum usum conlocationes.

7 Sin autem cuneorum adiectionibus et detractionibus correptiones dierum aut crescentiae ex cuneis non probabuntur fieri, quod cunei saepissime vitia faciunt, sic erit explicandum. In columella horae ex analemmatos transverse describantur, menstruaeque lineae columella signentur. Eaque columna versatilis perficiatur, uti ad sigillum virgulamque, qua virgula egrediens sigillum ostendit horas, columna versando continenter suis cuiusque mensibus brevitates et crescentias faceret horarum.

8 Fiunt etiam alio genere horologia hiberna, quae anaphorica¹ dicuntur perficiuntque rationibus his. Horae disponuntur ex virgulis aeneis ex analemmatos descriptione ab centro dispositae in fronte; in ea circuli sunt circumdati menstrua spatia finientes. Post has virgulas tympanum, in quo descriptus et depictus est mundus signiferque circulus descriptioque ex XII caelestium signorum fit figurata, cuius ex² centro deformatio, unum maius, alterum minus. Posteriori autem parti³ tympano medio axis versatilis est inclusus inque eo axi aenea mollis catena est involuta, ex qua pendet ex una parte phellos (sive

¹ anaphorica *H*.

² ex (e) *Joc* : & *H*.

³ parte *G* : parti *H S* : parti *abl*. Varro *R. R.* I. xiii. 5.

¹ When the sun is not shining.

by the lathe that one can enter and fit the other; the same rod, by loosening or tightening them, produces a strong or gentle current of water flowing into the vessels. Hence by this methodical contrivance, water-clocks are set up for use in the winter.¹

7. But if by adding or withdrawing wedges the shortening or lengthening of the days shall not be found to be correctly marked by using wedges (because very often the wedges are faulty), the solution must be reached as follows. The hours are to be indicated cross-wise on a small column, in accordance with the analemma. The lines of the months also are to be marked on the column. And this is to be made to revolve uninterruptedly, so that it turns to the figure and the rod (with which rod the figure as it moves on shows the hours), and so causes the shortening and lengthening of the hours, in their several months.

8. There are also made winter clocks of another kind, which are called Anaphorica, and they make them in the following fashion.² An analemma is described, and the hours are marked with bronze rods, beginning from a centre on the clock face. On this circles are described which limit the spaces of the months. Behind these rods there is a drum, on which the firmament and zodiac are drawn and figured: the drawing being figured with the twelve celestial signs. Proceeding from the centre the spaces are greater and less. On the back part in the middle of the drum is fixed a revolving axle. On the axle a pliable brass chain is coiled. On one end hangs a

² The figure indicates the relation of the various parts of the water-clock, Pl. N, Barbaro, *op. cit.* p. 435.

tympanum), qui ab aqua sublevatur, altera ¹ aequo pondere phelli sacoma saburrale.²

- 9 Ita quantum ab aqua phellos sublevatur, tantum saburrae pondus infra deducens versat axem, axis autem tympanum. Cuius tympani versatio alias efficit, uti maior pars circuli signiferi, alias minor ³ in versationibus suis temporibus designet horarum proprietates. Namque in singulis signis sui cuiusque ⁴ mensis dierum numeri cava sunt perfecta, cuius bulla, quae solis imaginem horologiis tenere videtur, significat horarum spatia. Ea translata ex terebratione in terebrationem mensis vertentis perficit cursum
- 10 suum. Itaque quemadmodum sol per siderum spatia vadens dilatat contrahitque dies et horas, sic bulla in horologiis ingrediens per puncta contra centri tympani versationem, cotidie cum transfertur aliis temporibus per latiora, aliis per angustiora spatia, menstruis finitionibus imaginis efficit horarum et dierum.

- De administratione ⁵ autem aquae, quemadmodum
- 11 se temperet ad rationem, sic erit faciendum. Post frontem horologii intra conlocetur castellum in idque per fistulam saliat aqua ⁶ et in imo habeat cavum. Ad id autem adfixum sit ex ⁷ aere tympanum habens foramen, per quod ex castello in id aqua influat. In eo autem minus tympanum includatur cardinibus ex torno masculo et femina inter se coartatis, ita uti minus tympanum quemadmodum epitonium in maiore circumagendo arte leniterque versetur.

¹ altera *Joc* : -ro *H*.

³ minor *Joc* : minus *H*.

⁵ administrationē *H*.

⁷ ex *ed* : & *H*.

² saburrale *Joc* : -li *H*.

⁴ cuiusque *ed* : usque *H*.

⁶ saliat quae *H*.

¹ For equilibrium as a mechanical principle, see Book X. i. 1.
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cork or drum raised by the water; on the other, a counterpoise¹ of sand equal in weight to the cork.

9. Thus, in so far as the cork is raised by the water, to that extent the weight of sand drags down and turns the axle, and the axle turns the drum. The revolution of this drum sometimes makes a greater part of the circle of the zodiac to indicate the proper length of the hour; sometimes a lesser part so to do. For in the several signs, holes are made to the number of the days of the several months; and the pin, which in dials seems to represent the sun, marks the spaces of the hours, and moving from one hole to another completes the course of the passing month. 10. Therefore just as the sun traversing the spaces of the constellations lengthens and contracts the days and hours,² so the index moving along the holes in the dial in the opposite direction to the revolving drum, passes daily sometimes over longer, sometimes over shorter spaces; thus it produces over the monthly periods the representation of the hours and days.

The supply of water and its adjustment to the machine is to be as follows. 11. Inside, behind the dial of the clock, a cistern³ is to be placed. The water is to enter by a pipe, and the cistern is to have a hole at the bottom. Against this at the side there is to be fixed a bronze drum with an opening, through which the water flows into it from the cistern. Within this is enclosed a lesser drum joined to it with tenon and socket, so that the lesser drum turning round within the greater, like a stopcock, fits closely and smoothly in its revolution.

¹ By the different lengths of the day in summer and winter.

³ *castellum*, a cistern or reservoir, Plin. *N.H.* XXXVI. 121.

- 12 Maioris autem tympani labrum aequis intervallis cccclxv puncta habeat signata, minor vero orbiculus in extrema circinatione fixam habeat ligulam, cuius cacumen dirigat ad punctorum regiones, inque eo orbiculo temperatum sit foramen, quia in tympanum aqua influit per id et servat administrationem. Cum autem in maioris tympani labro¹ fuerint signorum caelestium deformationes, id autem sit inmotum et in summo habeat deformatum cancri signum,² ad perpendicularum eius in imo capricorni, ad dextram spectantis³ librae, ad sinistram arietis signum,⁴ ceteraque inter eorum spatia designata sint, uti in caelo videntur.
- 13 Igitur cum sol fuerit in capricorni, orbiculi⁵ ligula⁶ in maioris tympani parte ex⁷ capricorni cotidie singula puncta tangens, ad perpendicularum habens aquae currentis vehemens pondus, celeriter per orbiculi foramen id extrudit ad vas. Tum⁸ excipiens eam, cum brevi spatio impletur, corripit et contrahit dierum minora⁹ spatia et horarum. Cum autem cotidiana versatione minoris¹⁰ tympani ligula ingrediatur in aquarii puncta,¹¹ descendant foramina perpendicularo et aquae vehementi cursu cogitur tardius emittere salientem. Ita quo minus celeri cursu vas excipit aquam, dilatat horarum spatia.

¹ libro *H* et *a. c. S.*

² cancri signū *S*: caneri signorū *H.*

³ spectantis *ed*: -tes *H.*

⁴ signum *rec*: signi *H.*

⁵ orbiculi *Perr*: -lo *H.*

⁶ ligula *H G^h*: lingula *L.*

⁷ ex *Kr*: & *H.*

⁸ vas tum *Joc*: vastum *H.*

⁹ dierum minoris spatia *H*: minora *e, ed.*

12. The edge of the greater drum is to have 365 points marked at equal intervals. The lesser drum is to have on its outside circumference a tongue fixed, and is to direct the tip towards the places of the points. In the same drum a proportionate perforation is to be adjusted, because the water flows through it into the drum and guides the working. Now since the representations of the signs of the zodiac are on the margin of the greater drum, this is to remain unmoved. The sign of Cancer is to be figured at the top; perpendicularly below it, the sign of Capricorn is at the bottom. On the right of the spectator, the sign of Libra; on his left, that of Aries. The other signs are to be marked within their spaces as they appear in the sky.

13. Therefore, when the sun is in Capricorn,¹ the tongue in the lesser drum touches every day the several points in Capricorn on that part of the larger drum. The great weight of the running water being vertical, is quickly delivered through the perforation of the lesser drum into the vessel. The vessel which receives the water is soon filled, and arrests and contracts the spaces of the days and hours. When, however, by the continuous revolution of the lesser drum, the tongue enters all the points in Aquarius, the perforations leave the perpendicular, and after the downpour the water is compelled to send forth its current more slowly. Thus the slower is the flow by which the vessel receives the water, the more it extends the length of the hours.

¹ *capricorni* sc. *signo*.

¹⁰ *minoris Barb : maioris H.*

¹¹ *in aquarii puncta Ro : in aquario cuncta H.*

- 14 Aquarii vero pisciumque punctis uti gradibus scandens orbiculi foramen in ariete tangendo octavam partem aqua temperate salienti praestat aequinoctiales horas. Ab ariete per tauri et geminorum spatia ad summa cancri puncta partis octavae foramen se¹ tympani versationibus peragens et in altitudinem eo rediens viribus extenuatur, et ita tardius fluendo dilatet morando spatia et efficit horas in cancri signo solstitiales. A cancro cum proclinat et peragit per leonem et virginem ad librae partis octavae puncta revertendo et gradatim corripiendo spatia contrahit horas, et ita perveniens ad puncta
- 15 librae aequinoctialis rursus reddit horas. Per scorpi-
onis vero spatia et sagittarii proclivius deprimens se foramen rediensque circumactione ad capricorni partem VIII, restituitur celeritate salientis ad brumales horarum brevitates.

Quae sunt in horologiorum descriptionibus rationes et adparatus, ut sint ad usum expeditiores, quam aptissime potui, perscripsi. Restat nunc de machinationibus et de earum principiis ratiocinari. Itaque de his, ut corpus emendatum architecturae perficiatur, insequenti volumine incipiam scribere.

¹ so *Ro* : seu *H*.

14. Then the perforation of the lesser drum mounts by the points of Aquarius and Pisces, as though up a staircase, and touches the eighth degree in Aries; the water duly marks the equinoctial hours by its outflow. From Aries, the perforation proceeding by the revolution of the drum and returning, by way of Taurus and Gemini, to the top points of Cancer at its eighth degree, loses its strength; thus the water flowing more slowly, by its delay is to lengthen the spaces, and so it produces the hours of the solstice in the sign of Cancer. When it inclines from Cancer and proceeds on its return through Leo and Virgo to the points of the eighth degree of Libra, it gradually limits the spaces and contracts the hours; arriving thus at the points of Libra it again restores the equinoctial hours. 15. Through the spaces of Scorpio and Sagittarius, the perforation drops more steeply, and returning in its revolution to the eighth degree of Capricorn, is restored by the swiftness of the current to the short winter hours.

The proportions and constructions used in making dials have now been described, as exactly as I could, with a view to their ready use. Now it remains to discuss machines and their principles. In the next book I will begin to describe these and thereby finish a complete encyclopaedia of architecture.

BOOK X

LIBER DECIMUS

1 NOBILI Graecorum et ampla civitate Ephesi lex vetusta dicitur a maioribus dura condicione sed iure esse non iniquo constituta. Nam architectus, cum publicum opus curandum recipit, pollicetur, quanto sumptui adsit¹ futurum. Tradita aestimatione magistratui bona eius obligantur, donec opus sit perfectum. Absoluto autem, cum ad dictum impensa respondit, decretis et honoribus ornatur. Item si non amplius quam quarta in opere consumitur, ad aestimationem est adicienda, de publico praestatur, neque ulla poena tenetur. Cum vero amplius quam quarta in opere consumitur, ex eius bonis ad perficiendum pecunia exigitur.

2 Utinam dii immortales fecissent, ea lex etiam P. R. non modo publicis sed etiam privatis aedificiis esset constituta! Namque non sine poena grassarentur inperiti, sed qui summa doctrinarum subtilitate essent prudentes, sine dubitatione profiterentur architecturam, neque patres familiarum inducerentur ad infinitas sumptuum profusiones, et ut e bonis eicerentur, ipsique architecti poenae timore coacti diligentius modum inpensarum ratiocinantes explicarent, uti patres familiarum ad id, quod praeparavissent, seu paulo amplius adicientes, aedificia expedirent.

¹ adsit futurum H.

¹ *Adsit futurum for sit futurum.*

BOOK X

PREFACE

1. IN the renowned and spacious Greek city of Ephesus, a law is said to have been made of old by the forefathers of the citizens, in harsh terms but not unjust. For when an architect undertakes the erection of a public work, he estimates at what cost it will be done.¹ The estimate is furnished, and his property is assigned to the magistrate until the work is finished. On completion, when the cost answers to the contract, he is rewarded by a decree in his honour. If not more than a fourth part has to be added to the estimate, the state pays it and the architect is not mulcted. But if more than a fourth extra is spent in carrying out the work, the additional sum is exacted from the architect's property.

2. Would that the Gods had impelled the Roman people to make such a law not only for public, but also for private buildings! In that case unqualified persons would not swagger abroad with impunity, but persons trained in entirely accurate methods would profess architecture with confidence. Nor would owners be led on to unlimited and lavish expenditure, so that they are even dispossessed of their property; and the architects themselves, controlled by the fear of a penalty, would be more careful in calculating and declaring the amount of the cost. In this way the owners would finish their buildings to the sum provided or with the addition

Nam qui quadringenta¹ ad opus possunt parare, si adicient centum, habendo spem perfectionis delectationibus tenentur; qui autem adiectione dimidia aut ampliore sumptu onerantur, amissa spe et inpena abiecta, fractis rebus et animis desistere coguntur.

3 Nec solum id vitium in aedificiis, sed etiam in muneribus, quae a magistratibus foro gladiatorum scaenicisque ludorum dantur, quibus nec mora neque expectatio conceditur, sed necessitas finito tempore perficere cogit, id est sedes spectaculorum velorumque inductiones sunt et ea omnia, quae scaenicis moribus per machinationem ad spectationis populo comparantur. In his vero opus est prudentia diligens et ingenii doctissimi cogitata, quod nihil eorum perficitur sine machinatione studiorumque vario ac sollerti vigore.

4 Igitur quoniam haec ita sunt tradita et constituta, non videtur esse alienum, uti caute summaque diligentia, antequam instituantur opera, eorum expendantur rationes. Ergo quoniam neque lex neque morum institutio id potest cogere et quotannis et praetores et aediles ludorum causa machinationes praeparare debent, visum mihi est, imperator, non esse alienum, quoniam de aedificiis in prioribus voluminibus exposui, in hoc, quod² finitionem summam corporis habet constitutam, quae sint principia machinarum, ordinata praeceptis explicare.

¹ quadringenta *ed*: quadraginta *H*.

² quod *Schn*: qui *H*.

¹ Augustus, 22 B.C., entrusted games to praetors, Dio Cassius, LIV. 2.

of a little more. For those who can provide 400,000 sesterces, and have to add 100,000, are content to be so bound, in the hope of completing the work: while those who are burdened with the addition of a half, or more of the expense, lose hope, and declining further expenditure are forced to give up with broken fortune and spirit.

3. And this defect is found not only in building, but also in the public spectacles which are given by magistrates; whether of gladiators in the forum, or of plays with a theatrical setting. In these neither delay nor expectation is permitted, but necessity compels the performance to take place within a fixed time. There is the seating for the shows, and there are the awnings to be drawn, and all those other things which, in accordance with theatrical tradition, are provided for popular spectacles by means of machinery. Herein the requisites are careful foresight and the resources of a highly trained intelligence. For nothing of this sort is done without mechanical contrivance to which an alert and masterly attention has been applied.

4. Therefore, since these things have so been handed down and determined, it does not seem irrelevant to elucidate their provision with care and all diligence before the work is entered upon. For since neither law nor custom can compel this, while every year the praetors¹ and aediles must prepare the machinery for the spectacles, I thought it not irrelevant, your Highness, after dealing with buildings in the former books, to explain in this book (which rounds off the entire completion of the treatise) what the principles of machinery are, and the rules which guide them.

I

1 MACHINA est continens e materia coniunctio maximas ad onerum motus habens virtutes. Ea movetur ex arte circulatorum rutundationibus, quam¹ Graeci *cyclicen cinesin* appellant. Est autem unum genus scansorium, quod graece *acrobaticon* dicitur; alterum spirabile, quod apud eos *pneumaticon* appellatur; tertium tractorium, id autem Graeci *baru ison* vocitant. Scansorum autem machinae ita fuerunt conlocatae, ut ad altitudinem tignis statutis et transversariis conligatis sine periculo scandatur ad apparatus spectationem; at² spirabile,³ cum spiritus ex⁴ expressionibus impulsus et plagae vocesque *organicos* exprimantur.

2 Tractorium vero, cum onera machinis pertrahuntur, ut⁵ ad altitudinem sublata conlocentur. Scansoria ratio non arte sed audacia gloriatur; ea catenationibus [et transversariis et plexis conligationibus]⁶ et erismatum⁷ fulturis continentur. Quae autem spiritus potestate⁸ adsumit ingressus, elegantes artis subtilitatibus consequetur⁹ effectus. Tractoria¹⁰ autem maiores et magnificentia plenas habet ad utilitatem opportunitates et in agendo cum prudentia summas virtutes.

¹ quē *H.* ² at *Ro*: ut *H.* ³ spirabilē *H.*, -lem *S.*

⁴ ex *Kr*: & *H.* ⁵ ut *S G*: aut *H G*.

⁶ et transversariis—conligationibus *interpolavit G*: om. *H S.*

⁷ erismatum *Joc*: chrismatorum *H.*

⁸ potestate *Joc*: -tē *H.*

⁹ consequetur *G*: -quentur *H S.* ¹⁰ *sc.* ratio.

¹ *συνεχής*, not involving action at a distance.

² *materia* is wrongly translated 'wood' by many writers; Gwilt is correct in translating 'materials.'

CHAPTER I

ON MACHINES AND INSTRUMENTS

1. A MACHINE is a continuous¹ material² system having special fitness for the moving of weights. It is moved by appropriate revolutions of circles, which by the Greeks is called *cyclice cinesis*. The first kind of machine is of ladders (in Greek *acrobaticon*); the second is moved by the wind (in Greek *pneumaticon*); the third is by traction (in Greek *baru ison*³ or equilibrium). Now scaling ladders⁴ are so arranged that when the uprights are placed to a height and cross-pieces are tied to them, men may safely ascend to inspect military engines. But we have wind instruments when moving air is driven forth by pressure, and musical beats and vocal sounds are uttered by instruments.

2. Machines of draught draw weights mechanically so that they are raised and placed at an elevation. The design of the ladder prides itself not only on artifice but on military daring. It depends on using tie-pieces and the support of stays. But the design which gains an impulse by the power of moving air reaches neat results by the scientific refinement of its expedients. The traction machines offer in practice greater adaptation which reaches magnificence, and when they are handled carefully, supreme excellence.

¹ This third principle is seen in the water-clock of Ctesibius, Book IX. viii. 8, where the weights of the clock are in equilibrium.

⁴ ἀκροβατῶ = 'to climb aloft': military phrase, Polyæn *scansor*, found in late Latin, to be left here; cf. late Gk. ἀκροβάτης.

- 3 Ex his sunt quae *mechanicos* alia *organicos* moventur. Inter machinas et organa id videtur esse discrimen, quod machinae pluribus operis¹ ut vi maiore coguntur effectus habenti, uti ballistae² torculariorumque prela; organa autem unius operae prudenti tactu perficiunt quod est propositum, uti scorpionis seu anisocyclorum³ versationes. Ergo et organa et machinarum ratio ad usum sunt necessaria, sine quibus nulla res potest esse non inedita.
- 4 Omnis autem est machinatio rerum natura procreata ac praeceptrice et magistra mundi versatione instituta. Namque ni advertamus⁴ primum et aspiciamus continentem⁵ solis, lunae, quinque etiam stellarum, natura machinata versarentur,⁶ non habuissemus interdum lucem nec fructum maturitatis. Cum ergo maiores haec ita esse animadvertissent, e rerum natura sumpserunt exempla et ea imitantes inducti rebus divinis commodas vitae perfecerunt explicationes. Itaque comparaverunt, ut essent expeditiora, alia machinis et earum versationibus, nonnulla organis, et ita quae⁷ animadverterunt ad usum utilia esse studiis, artibus, institutis, gradatim augenda doctrinis curaverunt.

¹ operis *Schn*: operib; *H*. ² uallistae *H*.

³ anisocyclorum *Joc*: latinis osciclorū *H*.

⁴ namque enim advertamus *H*.

⁵ vel ut alii vocant, firmamentum, *Quint.* III. 11. 1.

⁶ *asyndeton*.

⁷ itaq; *H*.

¹ The predecessor of the mediaeval arquebus.

² The brilliant conjecture of Giocondo based on late Gk. ἀνισόκυκλος.

³ Gwilt paraphrases: 'the master movements of the universe itself.' This striking conception of machinery as natural,

3. Of these machines, some are moved mechanically, others are used like tools. There seems to be this difference between machines and instruments, that machines are driven by several workmen as by a greater force producing its effects, for example, projectile engines or wine presses. But instruments carry out their purpose by the careful handling of a single workman, such as the turning of a hand balista¹ or of screws.² Therefore both instruments and machinery are necessary in practice and without them every kind of work is difficult.

4. Now all machinery is generated by Nature, and the revolution of the universe guides and controls.³ For first indeed, unless we could observe and contemplate the continuous motion of the sun, moon and also the five planets; unless⁴ these revolved by the device of Nature we should not have known⁵ their light in due season nor the ripening of the harvest. Since then our fathers had observed this to be so, they took precedents from Nature; imitating them, and led on by what is divine,⁶ they developed the comforts of life by their inventions. And so, they rendered some things more convenient, by machines and their revolutions, and other things by handy implements. Thus what they perceived useful in practice they caused to be advanced by their methods, step by step, through studies, crafts, and customs.

extends the concept of nature and completes the Stoic pantheism.

¹ Supply *ni* from above.

² *habeo*, 'to know,' Cic. *Rep.* II. 33: *matrem habemus, ignoramus patrem*; cf. $\chi\omega$.

³ Vitruvius states clearly here the inspiration of the craftsman.

- 5 Attendamus enim primum inventum de necessitate, ut vestitus, quemadmodum telarum organicis administrationibus conexus staminis ad subtemen non modo corpora tegendo tueatur,¹ sed etiam ornatus adiciat honestatem. Cibi vero non habuissimus abundantiam, nisi iuga et aratra bubus iumentisque omnibus essent inventa. Sacularumque et prelorum et vectium si non fuisset torcularis praeparatio, neque olei nitorem neque vitium fructum habere potuissemus ad iucunditatem, portationesque eorum non essent, nisi plostrorum seu serracorum per terram, navicularum per aquam inventae essent
- 6 machinationes. Trutinarum vero librarumque ponderibus examinatio reperta vindicat ab iniquitate iustis moribus vitam. Non minus quae sunt innumerabili modo rationes machinationum, de quibus non necesse videtur disputare, quando² sunt ad manum cotidianae, ut sunt molae,³ folles fabrorum, raedae, cisia, torni ceteraque, quae communes ad usum consuetudinibus habent opportunitates.⁴ Itaque incipiemus de is, quae raro veniunt ad manus, ut nota sint,⁵ explicare.

II

- 1 PRIMUMQUE instituemus de is, quae aedibus sacris ad operumque publicorum perfectionem necessitate comparantur. Quae fiunt ita. Tigna duo ad one-

¹ tueatur *Schn*: -antur *H*.

² quando *Gr*: quod non *H*.

³ molae *Ro*: motae *H*.

⁴ oportunitates *G S*: opportunitatib: *H*.

⁵ sunt *H*.

5. Let us first consider necessary inventions. In the case of clothing, by the organic arrangements of the loom, the union of the warp to the web not only covers and protects our bodies, but also adds the beauty of apparel. Again, we should not have plentiful food, unless yokes and ploughs had been invented for oxen and other animals. If windlasses, press-beams and levers had not been supplied to the presses, we should not have had clear oil or the produce of the vine for our enjoyment. And their transport would have been impossible, unless the construction of carts or waggons by land, and of ships by sea had been devised. 6. The equilibrium of balances and scales has been applied to free human life from fraud by the provision of just measures. Besides, there are innumerable mechanical devices about which it does not seem needful to enlarge (because they are to hand in our daily use), such as millstones, blacksmiths' bellows, waggons, two-wheeled chariots, lathes and so forth, which are generally suitable for customary use. Hence we will begin to explain, so that they may be known, machines which are rarely employed.

CHAPTER II

ON MACHINES DEPENDING ON EQUILIBRIUM

1. AND first we will explain the machines¹ which must be provided for temples, and for the execution of public works. These are made as follows. Two

¹ Sackur, *Vitruv. u. die Poliorketiker*, furnishes an excellent commentary on the tenth book of Vitruvius.

rum magnitudinem¹ ratione expediuntur. A capite a fibula coniuncta et in imo divaricata eriguntur, funibus in capitibus conlocatis et circa dispositis erecta retinentur. Alligatur² in summo troclea, quem³ etiam nonnulli rechamum dicunt. In trocleam induntur⁴ orbiculi <duo>⁵ per axiculos versiones habentes. Per orbiculum <summum>⁶ traicitur ductarius funis, deinde demittitur et traducitur circa orbiculum trocleae inferioris. Refertur autem ad orbiculum imum trocleae superioris et ita descendit ad inferiorem et in foramine eius religatur.⁷ Altera pars funis refertur inter imas machinae partes.

2 In quadris autem tignorum posterioribus, quo loci sunt divaricata, figuntur chelonia,⁸ in quae coiciuntur sucularum capita, ut faciliter axes versentur. Eae suculae proxime capita habent foramina bina ita temperata, ut vectes in ea convenire possint. Ad rechamum autem imum ferrei forfices religantur, quorum dentes in saxa forata accommodantur. Cum autem funis habet caput ad suculam religatum et vectes ducentes eam versant, funis <se>⁹ involvendo circum suculam extenditur et ita sublevat onera ad altitudinem et operum conlocationes.

3 Haec autem ratio machinationis, quod per tres orbiculos circumvolvitur, trispastos appellatur. Cum

¹ magnitudine *H.*

² alligatur . . . troclea *Joc* : alligantur . . . trocleae *H.*

³ quem *e₃* *ed* : quae *H.*

⁴ induntur *Joc* : induuntur *H.*

⁵ duo *add. Joc.*

⁶ summum *add. Joc.*

⁷ religatur *ed* : -gantur *H.*

⁸ chelonia *e₃* *ed* : helonia *H.*

⁹ *add. Joc.*

pieces of timber are carefully prepared, which answer to the size of the load. They are set up, connected¹ at the top with a brace, and spreading at the base. They are kept upright by ropes fastened at the top and adjusted round them. At the top a block is made fast: these some call *rechamus*. On this block two pulleys are fixed, which revolve upon axles. Over the top pulley the leading rope is passed. It is then let down and drawn round a pulley of the block below. It is returned to the lower pulley of the top block, and so comes again to the lower block and is secured to the eye of it. The other end of the rope belongs to the lower part of the machine.²

2. On the back faces of the timbers where they separate, socket-pieces are fixed, into which the ends of the windlasses are put, so that the axles may turn easily. The windlasses near their ends have two perforations so adjusted that handspikes can fit into them. To the bottom of the block, iron pincers are fixed, the teeth of which are adjusted to holes in the blocks of stone. Now when the rope has its end tied to the windlass, and the handspikes draw and turn the windlass, the rope in winding round the axle is made taut and so lifts up weights to their place in the work.

3. Now this kind of contrivance, because it is turned by three pulleys, is called *trispastos*.³ When,

¹ This passage seems to settle the reading *destinabantur, distinebantur* in Caes. B. G. IV. 17. 5; *binis utrimque fibulis ab extrema part destinabantur*, cf. Holmes *ad loc.* Caesar's account of the bridge was probably supplied by the engineer.

² The upper block seems to have had one pulley placed above the other. *imum* the superlative in a comparative sense. Neuburger, fig. 270.

³ sc. *rechamus*.

- vero in ima troclea duo orbiculi, in superiore tres versantur, id pentaspaston dicitur. Sin autem maioribus oneribus erunt machinae comparandae, amplioribus tignorum longitudinibus et crassitudinibus¹ erit utendum; eadem ratione in summo fibulationibus, in imo sucularum versationibus² expediendum. His explicatis antarii funes ante laxi conlocentur; retinacula super scapulas machinae longe disponantur, et si non erit, ubi religetur, pali resupinati defodiantur et circum fistucatione⁴ solidentur, quo funes alligentur. Troclea in summo capite machinae rudenti contineatur, et ex eo funis perducatur³ ad palum et quae est in palo trocleam inligata. Circa eius orbiculum funis indatur et referatur ad eam trocleam, quae erit ad caput machinae religata. Circum autem orbiculum ab⁴ summo traiectus funis descendat et redeat ad suculam, quae est in ima machina, ibique religetur. Vectibus autem coacta sucula versabitur, eriget per se machinam sine periculo. Ita circa dispositis funibus et retinaculis in palis haerentibus ampliore modo machina conlocabitur. Trocleae et ductarii funes, uti supra scriptum est, expediuntur.
- ⁵ Sin autem colossicotera amplitudinibus et ponderibus onera in operibus fuerint, non erit suculae committendum, sed quemadmodum sucula chelonis retinetur, ita axis includatur habens in medium tympanum amplum, quod nonnulli rotam

¹ grassitudinibus *H*.

² versationibus *Joc*: venationibus *H*.

³ funis perducatur *Rode*: funes pducantur *H*.

⁴ ab summo *Joc*: ad summo *H* (a s. *G*^e).

¹ sc. *μηχανήμα*, Baumeister, p. 1621.

however, there are two pulleys in the lower block and three in the upper block, it is called *pentaspaston*.¹ But if machines are to be prepared for greater loads, we must use longer and thicker timbers. In the same way we must use larger bolts at the top, and larger windlasses below. When all is made ready, the tackle,² which is previously loose, is to be attached; the cables are to be carried over the shoulders of the machine. If there is no place to which they may be fixed, sloping piles are to be driven into the ground and secured by ramming the ground round them; to them the ropes are to be attached. 4. The block at the top of the machine is to be attached by a cable. And a rope is to be taken from the top to the inclined pile and fastened to the block which is on the pile. Passing over its pulley the rope is to be carried back to the block which shall be bound to the top of the machine. After passing round the pulley the rope is to come down from the top and is to return to the windlass which is below, and bound there. The windlass being worked by handspikes will revolve: and of itself will raise the machine without danger. Thus the ropes are passed round, the cables are fixed to the piles and the machine is in position for use. The pulleys and the tackle are applied as it is described above.

5. If, however, the works involve loads of immense dimensions and weight, we must not trust to the windlass. But an axle held in sockets like the windlass is to be inserted having in the middle a large drum,³ which some call a wheel: the Greeks,

¹ Cf. *ansarii*, C.I.L. VI. 1016a.

² *multaque per trocleas et tympana pondere magno | commovet atque levi sustollit machina nisu.* Lucr. iv. 905-6.

appellant, Graeci autem *amphieren*,¹ alii *perithecium*
 6 vocant. In his autem machinis trocleae non eodem
 sed alio modo comparantur. Habent enim et in
 imo et in summo duplices ordines orbiculorum.
 Ita funis ductarius traicitur in inferioris² trocleae
 foramen, uti aequalia duo capita sint funis, cum erit
 extensus, ibique secundum inferiorem trocleam
 resticula circumdata et contenta utraeque partes
 funis continentur, ut neque <in dextram neque>³
 in sinistram partem possint prodire. Deinde capita
 funis referuntur in summa troclea ab exteriori parte
 et deiciuntur circa orbiculos imos et redeunt ad imum
 coiciunturque⁴ infimae trocleae ad orbiculos ex
 interiore parte et referuntur dextra sinistra; ad
 caput circa orbiculos summos redeunt.

7 Traiecti autem ab exteriori parte feruntur dextra
 sinistra tympanum in axe ibique, ut haereant,
 conligantur. Tum autem circa tympanum involutus
 alter funis refertur ad ergatam, et is⁵ circumactus⁶
 tympanum et axem. Se involvendo pariter exten-
 dunt, et ita leniter levant onera sine periculo.
 Quodsi maius tympanum conlocatum aut in medio
 aut in una parte extrema fuerit sine ergata, calcantes
 homines expeditiores⁷ habere poterunt⁸ operis
 effectus.

8 Est autem aliud genus machinae satis artificiosum
 et ad usum celeritatis expeditum, sed in eo dare
 operam non possunt nisi periti. Est enim tignum,
 quod erigitur et distenditur retinaculis quadrifariam.

¹ *amphieren* H: ἀμφίηρης ut ἀμφήκης Hesych.

² *inferioris* G: -res H, inferius S. ³ *add. Joc.*

⁴ *coniciuntur* H S. ⁵ *is* G S^o: *his* H S.

⁶ *circumactus* e, *Joc*: *circū auctus* H.

⁷ *expeditiores* *rec*: *expeditores* H.

amphieres, or otherwise *perithecium*. 6. In these machines the blocks¹ are made in a different way. For they have below and above two pulleys arranged vertically. The guide rope passes into a hole in the lower block in such a way that the rope when it is taut has its two ends equally long. The rope being passed round and secured to the lower block, both ends of the rope are secured so that they cannot swerve to the right or left. Then the ends of the rope are carried back on the outside of the upper block and are taken over its lower pulleys, and return below. They are passed from the inside to the pulleys of the lower block and are carried up right and left and return to the top round the highest pulleys.

7. Passing from the outside they are carried right and left of the drum on the axle, and are tied so as to hold there. Then another rope is wound round the drum and carried back to the capstan. This rope is turned round the drum and axle, winds itself up and the ends are stretched equally and so gently raise the loads in safety. But if a greater drum is fixed either in the middle or on one of the ends, the capstan is dispensed with, and the drum, being trodden by men, can produce results more quickly.

8. There is another² kind of machine ingenious enough and suitable for speedy use; but only skilled workmen can deal with it. A pole is set up and is kept upright by cables in four different directions.

¹ The pulleys are not side by side, but one above the other.

² Like a crane (ill. Neuburger, *op. cit.* 209). Plate O.

Sub retinaculo chelonia¹ duo figuntur, troclea funibus² supra chelonia¹ religatur, sub troclea regula³ longa circiter pedes duos, lata digitos sex, crassa quattuor supponitur. Trocleae ternos ordines orbiculorum in latitudine habentes conlocantur. Ita tres ductarii funes in machina⁴ religantur. Deinde referuntur ad imam trocleam et traiciuntur ex interiore parte per eius orbiculos summos. Deinde referuntur ad superiorem trocleam et traiciuntur ab⁵ exteriori parte in interiorem per orbiculos imos.

- 9 Cum descenderint ad imum, ex interiore⁶ parte et per secundos orbiculos traducuntur in extremum et referuntur in summum ad orbiculos secundos; traieci redeunt ad imum et per imum⁷ referuntur ad caput; traieci per summos redeunt ad machinam imam. In radice autem machinae conlocatur tertia troclea; eam autem Graeci *epagonta*, nostri *artemonem* appellant. Ea troclea religatur ad trocleae radicem habens orbiculos tres, per quos traieci funes traduntur hominibus ad ducendum. Ita tres ordines hominum ducentes sine ergata celeriter
10 onus ad summum perducunt. Hoc genus machinae polyspaston⁸ appellatur, quod multis orbiculorum circuituionibus et facilitatem summam praestat et celeritatem. Una autem statutio tigni hanc habet utilitatem, quod ante quantum velit et dextra ac sinistra a latere⁹ proclinando onus deponere potest.

Harum machinationum omnium, quae supra sunt scriptae, rationes non modo ad has res, sed etiam

¹ celonia *H.* ² funibus *Joc*: funis *H.*

³ regula *ed*: aregula *H.*

⁴ i.e. in summo machinae *Joc.*

⁵ ab: ad *H.*

⁶ ex interiore *Joc*: exteriori *H.*

⁷ et per imum *Gr*: & pimo *H.*

⁸ polyspastion *H.*

⁹ a latere *e₁*: adlatere *H.*

Where the cables meet at the top, two sockets are fixed; the block is fixed to the sockets with ropes. Under the block is put a piece of timber about two feet long, six inches wide, and four inches thick. The blocks, with three sets of pulleys in their width, are fixed so that three guide ropes are inserted in the machine. These are brought down to the lower block and pass from the side next the pole over the upper pulleys; thence they are carried to the upper block and pass over the lower pulley, from the outside to within.

9. When they come below they pass over the second pulleys from within outwards, and are brought back to the second pulleys above. Passing on they return below, and from below they return to the top. And passing over the top of the pulleys, they return to the lower part of the machine. Further, at the foot of the machine a third block is fixed; this is called *epagon* by the Greeks, *artemon*¹ by us. The block is secured to its foot with three pulleys, over which the ropes pass, which are given to men to work. Thus three sets of men working without a capstan quickly draw a load to the top. 10. This kind of machine is called *polyspaston*² (a compound pulley), because with its many pulleys it is very easy and quick to work. The use of a single pole has this advantage, that by inclining it beforehand it can deposit the load sideways right or left as much as is desired.

The use of all the contrivances described above is available not only for these purposes, but also for

¹ 'The guiding pulley of a machine for raising weights.'

² This machine was used by Archimedes in launching a ship for Hiero, Plut. *Marcellus*, 14.

ad onerandas et exonerandas naves sunt paratae, aliae erectae, aliae planae in carchesis versatilibus conlocatae. Non minus sine tignorum erectionibus in plano etiam eadem ratione et temperatis funibus et trocleis subductiones navium efficiuntur.

- 11 Non est autem alienum etiam Chersiphronos¹ ingeniosam rationem exponere. Is enim scapos columnarum e lapidicinis cum deportare vellet Ephesi ad Dianae fanum, propter magnitudinem onerum et viarum campestem mollitudinem non confisus carris,² ne rotae devorarentur, sic est conatus. De materia trientali scapos quattuor, duos transversarios interpositos,³ quanta longitudo scapi fuerit, complectet et conpeget⁴ et ferreos cnodacas⁵ uti subscudes in capitibus scaporum inplumbavit et armillas in materia ad cnodacas⁵ circumdandos infixit; item bucculis⁶ tigneis capita religavit; cnodaces⁵ autem in armillis inclusi liberam habuerunt versionem tantam; ita, cum boves ducerent subiuncti,⁷ scapi⁸ versando in cnodacibus et armillis sine fineolvebantur.

- 12 Cum autem scapos omnes ita vexerunt et instabant epistyliorum vecturae, filius Chersiphronos⁹ Metagenes transtulit ex scaporum¹⁰ vectura etiam in epistyliorum deductione. Fecit enim rotas circiter pedum duodenum et epistyliorum capita in medias

¹ crestiphonos *H.* ² carris *S*: caris *H.*

³ interpositos *ed*: interpostios *H.*

⁴ cōnpeget *G* (*alternis temporibus futuro et praeterito utitur H quasi sermone Semilico*).

⁵ cnodac- *Turn*: chodac- *H.*

⁶ bucculis *S*: bacculis *H.*

⁷ subiuncti *G*: -tis *H S.*

⁸ scapi *Joc*: scapo *H.*

⁹ cresiphonos *H.*

¹⁰ excaporum *H.*

loading up and unloading ships: some being upright, others on the level, being fixed with revolving sockets.¹ In like fashion on the level (without erecting poles) blocks and ropes are adjusted in order to draw ships ashore.²

11. It is quite germane to our subject to describe an ingenious contrivance of Chersiphron.³ When he desired to bring down the shafts of the columns from the quarries to the Temple of Diana at Ephesus, he tried the following arrangement. For he distrusted his two-wheeled carts, fearing lest the wheels should sink down in the yielding country lanes because of the huge loads. He framed together four wooden pieces of four-inch timbers: two of them being cross-pieces as long as the stone column. At each end of the column, he ran in iron pivots with lead, dovetailing them, and fixed sockets in the wood frame to receive the pivots, binding the ends with wood cheeks: thus the pivots fitted into the sockets and turned freely.⁴ Thus when oxen were yoked and drew the frame, the columns turned in the sockets with their pivots and revolved without hindrance.

12. Now when they had thus brought all the shafts, and set about bringing the architraves, Metagenes, the son of Chersiphron, applied the method of conveying the shafts to the transport of the lintels. For he made wheels about twelve feet in diameter, and

¹ *carchesium*: here it seems to mean the 'top' of a mast, or alternatively a similar socket or shoe resting on the ground. Cf. Lucr. v. 418: *summi carchesia mali*.

² Caes. B. G. IV. 29. 2.

³ Account probably based upon the treatise referred to, VII. *pref.* 12.

⁴ The frame contained the column, like the frame which contains a garden roller when it is drawn by a horse.

rotas inclusit; eadem ratione cnodaces¹ et armillas in capitibus inclusit: ita cum trientes a bubus ducerentur, in armillis inclusi cnodaces versabant² rotas, epistylia vero inclusa uti axes in rotis eadem ratione,³ qua scapi, sine mora ad opus pervenerunt. Exemplar autem erit eius, quemadmodum in palaestris cylindri exaequant ambulationes. Neque hoc potuisset fieri, nisi primum propinquitas esset—non enim plus sunt ab lapidicinis ad fanum milia passuum octo—nec ullus est clivus sed perpetuus campus.

- 13 Nostra vero memoria cum colossici Apollinis in fano basis esset a vetustate diffracta, et metuentes, ne cederet ea statua et frangeretur, locaverunt ex eisdem lapidicinis basim excidendam. Conduxit quidam Paconius. Haec autem basis erat longa pedes duodecim, lata pedes viii, alta pedes sex. Quam Paconius gloria fretus non uti Metagenes adportavit, sed eadem ratione alio genere constituit
- 14 machinam facere. Rotas enim circiter pedum xv fecit et in his rotis capita lapidis inclusit, deinde circa lapidem fusos sextantales⁴ ab rota ad rotam ad circinum compegit, ita uti fusus a fuso non distaret pedem esse unum. Deinde circa fusos funem involvit et⁵ bubus iunctis funem ducebant. Ita cum explicaretur, volvebat rotas, sed non poterat ad lineam via recta ducere, sed exhibat in unam

¹ chodaces *H.*

² versabant *ed*: -bant *H G.*

³ rationem *a. c. H.*

⁴ sextantales *Joc*: sextantes *H.*

⁵ et *ed*: ut *H.*

¹ Like a garden roller with a stone cylinder.

² Vitruvius' account of the temple is correct. It is unlikely that he was mistaken here. Wood, *op. cit.* 19, 265. There are quarries some miles up the Cayster on the left bank.

fixed the ends of the architraves in the middle of the wheels. In the same way he fixed pivots and sockets at the ends of the architraves. Thus when the frames of four-inch timber were drawn by the oxen, the pivots moving in the sockets turned the wheels, while the architraves being enclosed like axles in the wheels (in the same way as the shafts) reached the building without delay. (A similar machine¹ is used when rollers level the walks in the palaestrae.) This expedient would not have been possible unless, to begin with, the distance had been short. It is not more than eight miles from the quarries to the temple, and there are no hills but an unbroken plain.²

13. Within living memory, when the base of the colossal statue of Apollo in the temple had been cracked across by age, it was feared lest the statue should give way and be broken, and a contract was let out for cutting a base from the same quarries. A certain Paconius³ undertook the contract. The base was 12 feet long, 8 feet wide, 6 feet high. Paconius was so proud of his reputation that he did not convey it after the manner of Metagenes, but decided to construct a similar machine in another way.

14. He made two wheels about 15 feet in diameter and in them he enclosed the ends of the stone. Next, he fixed two-inch pieces less than a foot apart round the stone lengthwise from wheel to wheel. Then he wound a rope outside the wood pieces and drew the rope with a yoke of oxen. When the rope was pulled it caused the wheels to turn. However, he could not keep the machine straight along the road, but it kept

¹ The same name occurs Suet. *Tib.* 61.

partem. Ita necesse erat rursus retroducere. Sic Paconius ducendo et reducendo pecuniam contricavit, ut ad solvendum non esset.

- 15 Pusillum extra progrediar et de his lapidicinis, quemadmodum sint inventae, exponam. Pixodarus fuerat pastor. Is in his locis versabatur. Cum autem cives Ephesiorum cogitarent fanum Dianae ex marmore facere decernerentque, a Paro, Proconneso,¹ Heraclea, Thaso² uti marmor peteretur,³ propulsis ovibus Pixodarus in eodem loco pecus pascebat, ibique duo arietes inter se concurrentes alius alium praeterierunt et impetu facto unus cornibus percussit saxum, ex quo crusta candidissimo colore fuerat deiecta. Ita Pixodarus dicitur oves in montibus reliquisse et⁴ crustam cursim Ephesum, cum maxime de ea re ageretur, detulisse. Ita statim honores decreverunt ei et nomen mutaverunt: pro Pixodaro Euangelus nominaretur. Hodieque quotmensibus magistratus in eum locum proficiscitur et ei sacrificium facit, et si non fecerit, poena tenetur.

III

- 1 De tractoriis rationibus quae necessaria putavi, breviter exposui. Quorum motus et virtutes duae

¹ proconesso H.

² Thaso *ed*: thasii H.

³ marmor peteretur *Mar*: marmo|rep&at H.

⁴ reliquiss& crustam H.

¹ Callistratus, another transport contractor, had a similar experience. *Athen. Mech.* 7.

² *trico*, *Vulg. Eccclus.* xxxii. 15.

swerving to one side.¹ Thus it was necessary to draw it back again. So Paconius by drawing it backwards and forwards frittered² his money away and went bankrupt.

15. I will make a small digression, and describe how these quarries were discovered. Pixodarus was a shepherd who lived in this neighbourhood. Now when the citizens of Ephesus planned to build a temple of marble and decided to obtain marble from Paros, Proconnesus, Heraclea, and Thasos, Pixodarus was driving his sheep and was pasturing them in the same place. And there two rams, butting together, overran one another, and, in the rush, one of them struck a rock with his horns and a chip of the whitest³ colour was thrown down. So Pixodarus is said to have left his sheep on the hills and to have run with the chip of marble to Ephesus at the time when there was a great discussion about the matter. Thus the citizens decreed him divine honours⁴ and changed his name: instead of Pixodarus he was to be named Evangelus. And to this day every month the magistrate sets out to that place and sacrifices to Evangelus. If he omits to do so he is subject to a penalty.

CHAPTER III

ON RECTILINEAR AND CIRCULAR TRACTION

1. I HAVE set forth briefly what I thought necessary about methods of Traction. Of these, the effective movements⁵ are two distinct and unlike

³ White and black are colours, although not always regarded as such by the physicist.

⁴ Acts, xiv. 11. ⁵ *motus et virtutes*, hendiadys.

res diversae et inter se dissimiles uti congruentes uti principia pariunt eos perfectus: una porrecti, quam Graeci *eutheiam* vocitant, altera rutunditatis, quam Graeci *cycloten*¹ appellant. Sed vero neque sine rutunditate motus porrecti nec sine porrecto rotationis versationes onerum possunt facere levationes.

2 Id autem ut intellegatur, exponam. Inducuntur uti centra axiculi in orbiculos et in trocleis conlocantur, per quos orbiculos funis circumactus directis ductionibus et in sucula conlocatus vectium versationibus onerum facit egressus in altum. Cuius suculae cardines uti centra porrecti in cheloniis,² foraminibusque eius vectes conclusi capitibus ad circumum circumactis torni ratione versando faciunt oneris elationes. Quemadmodum etiam ferreus vectis cum est admotus ad onus, quod manuum multitudo non potest movere, supposita uti centro citro³ porrecta pressione, quod Graeci *hypomochlion* appellant, et lingua sub onus subdita, caput eius unius hominis viribus pressum id onus extollit.

3 Id autem quod brevior pars prior vectis ab ea pressione, quod est centrum, subit sub onus, et quo longius ab eo centro distans caput eius deducitur.⁴ Per id faciundo motus circinationis cogit pressionibus

¹ κυκλωτήν *Joc* : cycloeten *H*.

² cheloniis *S* : caeloniis *H*.

³ citro *adj. Gr.* : cito *H*.

⁴ deducitur per id *Ro* : per id deducitur *H*.

¹ The whole of the rest of this chapter seems to derive from the *Mechanica* (attributed wrongly to Aristotle), 850a-852a.

things, although they are co-operating principles in producing their results. There is the principle of the *straight* line (which the Greeks call *eutheia*); and that of the *circle* (which the Greeks call *cyclotes*). But neither rectilinear motion without circular, nor rotating movements without rectilinear, can produce the raising of loads.

2. I will illustrate this so as to make it understood. Axles are fixed as centres for the pulleys and fitted into blocks. The rope is taken round over the pulleys and drawn straight down; and being coiled round a windlass, when the levers are turned, causes the load to rise upwards. The pivots of the windlass being inserted, like centres, into the sockets, the levers are inserted into holes in the windlass, and their ends being pushed round in a circle and turning like a lathe, cause the movement upwards of the loads. After the same fashion, when an iron lever¹ is applied to a weight which a multitude of hands could not move, a fulcrum² is placed under it on the nearer side as a centre (which the Greeks call *hypomochlion*). The short end of the lever is placed under the load, and the long end of the lever, when it is pressed down by one man's strength, raises the load.

3. Now this lifting is accomplished because the short end of the lever is under the weight, and is nearer to the fulcrum where is the centre of motion; and in so far as the head of the lever which is pressed down is further distant from the fulcrum. When the lever is in action, the circular motion (*i.e.* of the

¹ *pressio*, Caes. B.C. II. 9. 6. Caesar here again, as in the case of the Rhine bridge, uses the technical knowledge of his engineers.

examinare paucis manibus oneris maximi pondus. Item si sub onus vectis ferrei lingula subiecta fuerit neque eius caput pressione in imum, sed adversus in altitudinem extolletur,¹ lingula fulta in areae solo habebit eam pro onere, oneris autem ipsius angulum² pro pressione. Ita non tam faciliter quam per oppressionem, sed adversus nihilominus in pondus oneris erit exercitatum. Igitur si plus lingula vectis supra hypomochlion posita sub onus subierit et caput eius propius³ centrum pressiones habuerit, non poterit onus elevare, nisi, quemadmodum supra scriptum est, examinatio vectis longitudinis per caput neque ductionibus fuerit facta.

- 4 Id autem ex trutinis, quae staterae dicuntur, licet considerare. Cum enim ansa propius caput, unde lancula pendet, ibi⁴ ut centrum est conlocata et aequipondium in alteram partem scapi, per puncta vagando quo longius aut etiam ad extremum perducitur, paulo et impari⁵ pondere amplissimam pensionem parem⁶ perficit per scapi librationem, et examinatio longius ab centro recedens ita inbecillior.⁷ Aequipondii brevitatem maiorem vim ponderis momento deducens sine vehementia molliter ab imo susum versum egredi cogit futurum.

¹ extolletur rec : -litur H.

² post angulum H folii 145 paginam aversam propter membranae tenuitatem vacuum habet ; in qua primum cruz (Vol. I. pref. xvii) delineata cui tenuitas nihil obstat, multis annis post scriptor incertus addidit Goderân' pposit' a sinistro crucis, a dextro fortasse codex, quasi in bibliothecae indice.

³ propius H.

⁴ ibi Mar : ubi H.

⁵ et impari Rode : etiam pari H.


⁶ parem Joc : parte H.

⁷ inbecilliora equipondii H.

¹ A blank page was left in H. 145b. See Vol. I. pref. xvii. This probably contained a diagram of two positions of the

lever)¹ round the fulcrum causes the weight of a great load to be balanced by a few hands.² Also if the short arm of an iron lever is put under the load, and the long arm is raised from the fulcrum upwards against the load, instead of downwards, the short arm resting upon the ground, will have that for a load, and the corner of the actual load for a fulcrum. Thus—not so easily indeed as by pressing against the actual fulcrum—none the less by pressing against the weight of the load, the work will be done. Therefore if the shorter end of the lever, being applied above the fulcrum, goes too far under the load, and the longer arm has the fulcrum too near the centre, it will not be able to raise the load, unless (as it has been written above) the long arm of the lever is balanced from the end, and not by pressing down the centre.

4. We can consider this in the case of steel-yards which are called *staterae*. For when the handle of suspension is placed like a centre, nearer the end of the beam from which the scale hangs, and the weight moves along the points marked on the other side of the centre, the further it is taken (or even to the end), with a small and unequal weight, it is made equal to a very large weight by bringing the beam to a level. The further the balancing weight retreats from the centre, to that extent may it be of slighter amount. The small counter-weight brings down, as it moves, the more powerful weight, and causes it to rise gently and without violence up and down.

lever in the form of a cross  which was worked over by the illuminator.

² When a lever is in motion the weight moved and the weight causing motion tend to be inversely proportionate to the lengths of the two arms measured from the fulcrum.

- 5 Quemadmodum etiam navis onerariae maximae gubernator ansam gubernaculi tenens, qui *οιαx*¹ a Graecis appellatur, una manu momento per centrum ratione pressionibus artis agitans, versat eam amplissimis et inmanibus mercis et pinus ponderibus oneratam. Eiusque vela cum sunt per altitudinem mediam mali² pendentia, non potest habere navis celerem cursum, cum autem in summo cacumine antennae subductae sunt, tunc vehementiore progreditur impetu, quod non proxime calcem mali, quod est loco centri, sed in summo longius et ab eo progressa recipiunt in se vela ventum.³
- 6 Itaque uti vectis sub onere subiectus, si per medium premitur, durior est neque incumbit, cum autem caput eius summum deducitur, faciliter onus extollit, similiter vela, cum sunt per medium temperata, minorem habent virtutem, quae autem in capite mali summo conlocantur discedentia longius a centro, non acriore sed eodem flatu, pressione cacuminis vehementius cogunt progredi navem. Etiam remi circa scalmos strophis religati, cum manibus impelluntur et reducuntur, extremis progredientibus a centro parvis maris undis spumam impulsu vehementi protrudunt porrectam navem, secante prora liquoris raritatem.
- 7 Onerum vero maxima pondera, cum feruntur a phalangariis hexaphoris et tetraphoris,⁴ examinantur per ipsa media centra phalarum, uti in diviso

¹ *οιαx* *Joc*: nox *H*.

² mediam mali *Joc*: mediā ali *H*, media mali *G S*.

³ vela ventum *Joc*: velamentū *H*.

⁴ exaphoris et raphoris *H*.

¹ Ciceronian phrase is *ingens immanisque*.

5. Just as also the steersman of a great merchant vessel holds the handle of the tiller (which is called *οἶα* by the Greeks) with only one hand, and moves it skilfully round the centre where the fulcrum is tightly set, and guides the ship laden with an abundant or indeed enormous¹ cargo of merchandise and timber.² Further, when the sails are only half-mast high, the ship cannot run swiftly; but when the yard-arms are drawn up to the tops of the masts, the ship sails with a more vehement course, because the sails take the wind, not near the foot of the mast (which is like a fulcrum), but at the mast-head from which the distance is greater.

6. Therefore just as when a lever is put under a load and pressed down about the middle, it is moved with difficulty, but when the longer arm is pressed down from the top, it easily raises the load; so when the sails are set half-mast high, they are less effective, but when they are set at the mast-head at a greater distance from the centre, without any further rising of the wind, with the summit as fulcrum, they cause the ship to sail a stronger course. When also the oars of a ship are tied to the tholes with loops, and pushed backwards and forwards, the ends of the blades,³ moving at a distance from the centre in the waves of the sea, drive the ship with a mighty impulse straight through the foam, as the bows cleave the yielding waters.

7. Again, when very heavy loads are carried by gangs of four or six porters, they are balanced exactly in the middle of the carrying-poles, so that

¹ *pinus* 'timber' used generically.

² *parma* and *palma* interchanged in MSS.; cf. *πάλημα* Hesych. for *πάριον*.

oneris solido pondere certa quadam divisionis ratione aequas partis collis singuli ferant operarii. Mediae¹ enim partes phalangerum, quibus lora tetraphororum invehuntur, clavis sunt finitae, nec labuntur in unam partem. Cum enim extra finem centri promoventur, premunt eum locum, ad quem propius² accesserunt, quemadmodum in statera pondus, cum examine progreditur ad fines ponderationum.

- 8 Eadem ratione iumenta, cum iuga eorum subiugiis³ loris per medium temperantur, aequaliter trahunt onera. Cum autem in pares sunt eorum virtutes et unum plus valendo premit alterum, loro trajecto fit una pars iugi longior, quae inbecilliori⁴ auxiliatur iumento. Ita in phalangis⁵ et iugis cum in medio lora non sunt conlocata sed in una parte, qua progreditur⁶ lorum ab medio,⁷ unam brevior, <alteram>⁸ efficit partem longiorem. Ea ratione si per id centrum, quo loci perductum est lorum, utraque capita circumaguntur,⁹ longior pars ampliorem, brevior minorem agit circinationem.

- 9 Quemadmodum vero minores rotae¹⁰ duriores et difficiliiores habent motus, sic phalangae et iuga, in quibus partibus habent minora a centro ad capita intervalla, premunt duriter colla, quae autem longiora habent ab eodem centro spatia, levant oneribus et trahentes¹¹ et ferentes. Cum haec ita ad

¹ mediae *G*^c: media *H*.

² proprius *H*.

³ subiugiis *Schn*: subiugiorum *H*.

⁴ inbecilliori *h*: -lior *H*.

⁵ phalangis *S*: palangis *H*.

⁶ progredit *H S*^c.

⁷ ad medio *H*.

⁸ alteram *G*.

⁹ circumaguntur *Joc*: -gentes *H*.

¹⁰ rotae *ed*: notae *H*.

the undivided solid weight is shared in a definite proportion, and each labourer carries an equal part of the load on his neck. For the middle parts of the carrying-poles, on which the straps of the porters are fixed, are provided with pegs so that the straps do not slip out of their place. For when the load slips away from the middle, it presses upon that side to which it is nearer, just as in the case of the weight on a balance when it is adjusted nearer one end of the beam.

8. In the same way, yokes of oxen draw their loads evenly, when the yokes are arranged about the middle, by the thongs of the yoke-straps. But when the strength of the oxen is not equal, and one by its greater pull burdens the other, the thong is moved on so that one part of the yoke is longer so as to help the weaker beast. Thus in the case of carrying-poles¹ and yokes, when the suspending thong is not placed in the middle but on one side, where the thong departs from the middle, it renders one side shorter and the other longer. By this means when the two arms of the yoke turn about the centre at which the thong is placed, the longer part describes a greater circle, the shorter arm a less.

9. Now just as smaller wheels are harder and more awkward to turn, so when carrying-poles and yokes have a less interval from the centre to the end of the arm, they press upon the neck, but those which have longer spaces from the same centre, ease off the load both in hauling and carrying. Since

¹ *phalanga*, in the sense of 'roller,' Caes. *B.C.* II. 10. It seems only to occur in the plural.

¹¹ et trahentes *Mar* : extrahentes *H*.

VITRUVIUS

centrum porrectionibus et circinationibus reciperent motos,¹ tunc vero etiam plostra, raedae, tympana, rotae, cocleae, scorpionis, ballistae, prela ceteraque machinae isdem rationibus per porrectum centrum et rotationem circini versantum faciunt ad propositum effectus.

IV

- 1 Nunc de organis, quae ad hauriendam aquam inventa sunt, quemadmodum variis generibus conparentur, exponam. Et primum dicam de tympano. Id autem non alte tollit aquam, sed exhaurit expeditissime multitudinem magnam. Ad tornum aut circinum fabricatus <axis,>² capitibus lamna ferratis, habens in medio circa se tympanum ex tabulis inter se coagmentatis, conlocatur in stipitibus habentibus in se sub capita axis ferreas lamminas. In eius tympani cavo interponuntur octo tabulae transversae tangentes axem et extremam tympani circuitiorem,
- 2 quae dividunt aequalia³ in tympano spatia. Circa frontem eius figuntur tabulae, relictis semipedalibus aperturis ad aquam intra concipiendam. Item secundum axem columbaria fiunt excavata in singulis spatiis ex una parte. Id autem cum est navali ratione picatum, hominibus calcantibus versatur et hauriendo per aperturas, quae sunt in frontibus tympani, reddit per columbaria secundum axem supposito labro ligneo habente una secum coniunctum canalem. Ita hortis ad inrigandum vel ad salinas ad temperandum praebetur aquae multitudo.

¹ motos *H*: (cf. *Am. Apoc.* XI. 13, terrae moto).

² add. *Joc.*

³ equalia *e*₂: aequali *H*.

¹ *E.g.* the wheels of a cart.

² Plate P from Fra Giocondo.

in this way such contrivances take movements at a centre, both rectilinear and circular, so also waggons, carts, drum-wheels and other wheels, screws, scorpions, balistae, presses and other machines produce the desired effect with parts moving about a centre along a straight line¹ and by a rotation round it.

CHAPTER IV

ON MACHINES FOR RAISING WATER, AND FIRST
THE TYMPANUM

1. I WILL now explain the machines which have been invented for raising water and how they are contrived in their different kinds. And first I will speak of the *tympanum*.² Now this does not raise the water to a great height, but draws a large amount in a short time. The axle is wrought in a lathe or made circular by hand and its ends are hooped with iron bands. Round the middle it has a drum of planks fitted together; and it is placed upon posts cased with iron, under the ends of the axle. Within the drum are inserted eight cross-pieces going from the axle to the circumference of the drum, and these are arranged round the drum at equal intervals.

2. Around the rim of the drum, boards are fixed with six-inch openings to receive the water. Further, along the axle, holes are cut, one for each bay. When it has been tarred ship-fashion, it is turned by men on a treadmill. The water which is drawn through the openings in the outside of the drum is delivered also through the holes next to the axle into a wooden basin having a trough connected with it. Thus an abundant supply of water is furnished for irrigating gardens, or for diluting salt in salt pits.

- 3 Cum autem altius extollendum erit, eadem ratio communicabitur. Sic rota fiet circum axem eadem magnitudine, ut ad altitudinem, quae opus fuerit, convenire possit. Circum extremum latus rotae figentur modioli quadrati pice et cera solidati. Ita cum rota a calcantibus versabitur, modioli pleni ad summum elati¹ rursus ad imum revertentes infundent⁴ in castellum ipsi per se quod extulerint.² Sin autem magis altis³ locis erit praebendum, in eiusdem rotae axe involuta duplex ferrea catena demissaque ad imum libramentum conlocabitur, habens situlos pendentes aereos congiales. Ita versatio rotae catenam in axem involvendo efferet situlos in summum, qui <cum>⁴ super axem pervehuntur, cogentur inverti et infundere in castellum aquae quod extulerint.²

V

- 1 FIUNT etiam in fluminibus rotae eisdem⁵ rationibus, quibus supra scriptum est. Circa earum frontes adfiguntur pinnae, quae, cum percutiuntur ab impetu fluminis, cogunt progredientes versari rotam, et ita modiolis haurientis et in summum referentes sine operarum calcatura ipsius fluminis impulsu versatae praestant, quod opus est ad usum.
- 2 Eadem ratione etiam versantur hydraletae,⁶ in quibus eadem sunt omnia, praeterquam quod in uno capite axis tympanum dentatum est⁷ inclusum.

¹ elati *rec* : &lati *H S*.

² extulerint *S* : extullerint *H*.

³ altis *Joc* : aliis *H*.

⁴ *add. Joc.*

⁵ eisdem *e₂* : eiusdē *H*.

3. When, however, the water is to be raised to a greater height, a similar method will be employed. A wheel is so constructed round the axle of such a size as shall suit the height required. Round the circumference of the wheel square buckets are to be fixed, made taut with pitch and wax. Thus, when the wheel is turned by men treading it, the buckets are raised full to the top, and on their return down, pour into a conduit what they have raised.

4. But if a supply is required at a still greater height, a double iron chain is made to revolve on the axle of the same wheel and let down to the lower level, with bronze buckets suspended to the chain, each holding 3 quarts. Thus the turning of the wheel makes the chain revolve round the axle, and carries the buckets to the top. These are carried over the axle; they are made to turn over and pour into the conduit the water they have raised.

CHAPTER V

ON MILL WHEELS

1. WHEELS are used in rivers in the same way as described above. Round the outside, paddles are fixed, and these, when they are acted on by the current of the river, move on and cause the wheel to turn. In this fashion they draw up the water in buckets and carry it to the top without workmen to tread the wheel. Hence, being turned by the force of the river only, they supply what is required.

2. Mill wheels are turned on the same principle, except that at one end of the axle a toothed drum is

^a *hydraletae Schn* : *hydraulae H.*

^r *est Schn* : & *H.*

Id autem ad perpendicularum conlocatum in cultrum versatur cum rota pariter. Secundum id tympanum maius item dentatum planum est conlocatum, quo continetur. Ita dentes tympani eius, quod est in axe inclusum, impellendo dentes tympani plani¹ cogunt fieri molarum² circinationem. In qua machina impendens infundibulum³ subministrat molis frumentum et eadem versatione subigitur farina.

VI

- 1 Est autem etiam cocleae ratio, quae magnam vim haurit aquae, sed non tam alte tollit quam rota. Eius autem ratio sic expeditur. Tignum sumitur, cuius tigni quanta rata est⁴ pedum longitudo, tanta digitorum expeditur crassitudo. Id ad circinum rutundatur. In capitibus circino dividuntur circumtiones eorum tetrantibus et octantibus in partes⁵ octo, eaeque lineae ita conlocentur, ut plano posito tigno utriusque capitis ad libellam lineae inter se respondeant, et quam magna pars sit octava⁶ circinationis tigni, tam magna spatia decidantur⁷ in longitudinem. Item tigno plano conlocato lineae ab capite ad alterum caput perducantur ad libellam convenientes. Sic et in rotundatione et in longitudine aequalia spatia fient. Ita quod loci describuntur lineae, quae sunt in longitudinem⁸ spectantes, facient decusationes et in decusationibus finita puncta.

¹ plani *Joc* : plane *H*. ² molarum *S* : malarum *H G*.

³ infundibulū *H*. ⁴ rata est *Gr* : ratus *H*.

⁵ partes *Joc* : pedes *H*. ⁶ octava *Joc* : -vae *H*.

⁷ dicidantur *H G*. ⁸ longitudinem *Schn* : -ne *H*.

fixed. This is placed vertically on its edge and turns with the wheel. Adjoining this larger wheel there is a second toothed wheel placed horizontally by which it is gripped. Thus the teeth of the drum which is on the axle, by driving the teeth of the horizontal drum, cause the grindstones to revolve. In the machine a hopper is suspended and supplies the grain, and by the same revolution the flour is produced.

CHAPTER VI

ON THE WATER SCREW

1. THERE is further an application of the screw which draws a large amount of water, but does not raise it as high as the wheel. The contrivance¹ is as follows. A beam is taken as many inches thick as it is feet long. This is rounded to an exact circle. At the ends the circumference is to be divided by a compass into quadrants and eighths and so to eight parts; and the diagonals are to be so drawn that when the beam is horizontal the lines at either end correspond exactly. The whole length is to be marked off into spaces equal to one-eighth of the circumference. Again, the beam is to be laid level and lines are to be drawn from one end to the other guided by a level. Thus there will be equal divisions both round the beam and along it. Where the longitudinal lines are drawn, they will intersect the cross-lines, and these intersections are to be marked by points.

¹ Plate Q from Fra Giocondo. A similar illustration is given in *p*, a Parisian MS. assigned by Rose to XI or XII c; it should rather be dated c. 1500. The illustration was probably contemporary with Fra Giocondo.

2 His ita emendate descriptis sumitur saligna tenuis aut¹ de vitice secta regula, quae uncta liquida pice figitur in primo decusis puncto. Deinde traicitur oblique ad insequentes longitudinis et circumitionis² decusis, item ex ordine progrediens singula³ puncta praetereundo et circum involvendo conlocatur in singulis decusationibus, et ita pervenit et figitur ad eam lineam recedens a primo in octavum punctum, in qua prima pars est eius fixa. Eo modo quantum progreditur oblique spatium et per octo puncta, tantundem et longitudine procedit ad octavum punctum. Eadem ratione per omne spatium longitudinis et rutunditatis singulis decusationibus oblique fixae regulae per octo crassitudinis divisiones involutos faciunt canales et iustam cocleae naturalemque imitationem.

3 Ita per id vestigium aliae super alias figuntur unctae pice liquida, et exaggerantur ad id, uti longitudinis octava pars fiat summa crassitudo. Supra eas circumdantur et figuntur tabulae, quae pertegant eam involutionem. Tunc eae tabulae pice saturantur et lamminis ferreis conligantur, ut ab aquae vi ne dissolvantur. Capita tigni ferrea. Dextra autem ac sinistra cocleam tigna conlocantur in capitibus utraque parte habentia transversaria confixa. In his foramina ferrea⁴ sunt inclusa inque ea inducuntur styli, et ita cocleae hominibus calcanti-
4 bus faciunt versationes. Erectio autem eius ad inclinationem sic erit conlocanda, uti, quemadmodum Pythagoricum trigonum orthogonium describitur,

¹ aut *G*: ut *H*.

² longitudinis et circumitionis *Mar*: longitudes et circumitiones *H*.

³ singula *e*, *ed*: -li *H*.

⁴ ferrea *Ro*: ferret *H*.

2. When these points are accurately marked in this way, there is taken a thin strip of willow or osier and this being smeared with liquid pitch is fixed upon the first intersection. Thence it is drawn across obliquely to the next intersections of the longitudinal and circular line. In like manner proceeding in due course it passes the successive points and winds round them, being fixed at the several intersections. Thus moving back from the first to the eighth point it reaches and is fixed on the line in which the first part of it was fixed. In this way, as far as it advances obliquely through eight points of the circumference, so far it proceeds longitudinally to the eighth point. In the same manner, throughout the whole distance of the length and of the circumference, strips of wood are fixed obliquely at the several intersections and make channels which wind round through the eight divisions of the thickness: thus forming an accurate and natural imitation of a spiral shell.

3. Then along this track, strips are fixed one above another and smeared with liquid pitch, and are piled up until the entire thickness is one-eighth the length. Above the strips, planks are placed all round and fixed to cover the winding strips. Then the planks are soaked in pitch and bound together with iron hoops to protect them against the effect of the water. The ends of the wood are covered with iron. On the right and left of the screw, beams are placed at the ends, with cross-pieces placed on either side. In these are iron sockets into which the pivots of the screws are inserted, and so the screws are made to turn by a treadmill. 4. The fixing of the screw is to be done at such a slope that it corresponds to the manner in which the Pythagorean right-angled

sic id habeat responsum, id est uti dividatur longitudo in partes v, earum trium extollatur caput cocleae; ita erit ab perpendicularo¹ ad imas naris spatium earum partium² iii. Qua ratione autem oporteat id esse, in extremo libro eius forma descripta est in ipso tempore.

Quae de materia fiunt organa ad hauriendam aquam, quibus rationibus perficiantur quibusque rebus motus recipientia praestent versationibus ad infinitas utilitates, ut essent notiora, quam apertissime potui, perscripta sunt in illo tempore.

VII

- 1 INSEQUITUR nunc de Ctesibica machina, quae in altitudinem aquam educit, monstrare. Ea sit ex aere. Cuius in radicibus modioli fiunt gemelli³ paulum distantes, habentes fistulas furcillae figura⁴ similiter cohaerentes, in medium catinum concurrentes. In quo catino fiant asses in superioribus naribus fistularum coagmentatione subtili conlocati, qui praeobturantes⁵ foramina narium⁶ non patiuntur quod spiritu⁷ 2 in catinum est expressum. Supra catinum paenula ut infundibulum⁸ inversum est attemperata et per fibulam cum catino cuneo traiecto continetur, ne vis inflationis aquae eam cogat elevari.⁹ Insuper

¹ a perpendicularo *Joc*: adpendiculū *H*.

² partium *Mar*: pedes *H*.

³ gememelli *H*.

⁴ furcillae sunt figura *H*: (sunt *del. Ro*).

⁵ praeobdurantes *H*.

⁶ foraminariū *H*.

⁷ spiritu *Joc*: -tus *H*.

⁸ infudibulū *H*.

⁹ elevari *Schn*: -re *H*.

triangle is described¹: that is, the length is to be divided into 5 parts of which the head of the screw is to be raised three. Thus there will be, between the perpendicular and the lower mouth, a length of 4 parts. How this is to be done is shown by a diagram at the end² of the book.

And there I have displayed as clearly as I could for information the contrivances made of wood for drawing water, their construction and the means by which they are moved so as to furnish very great advantages.

CHAPTER VII

ON THE WATER MACHINE OF CTESIBIUS³

1. WE next proceed to describe the Ctesibian machine⁴ which raises water to a height. It is to be of bronze. The lower part consists of two similar cylinders at a small distance apart, with outlet pipes. These pipes converge like the prongs of a fork, and meet in a vessel placed in the middle. In this vessel valves are to be accurately fitted above the top openings of the pipes. And the valves by closing the mouths of the pipes retain what has been forced by air into the vessel. 2. Above the vessel, a cover like an inverted funnel is fitted and attached, by a pin well wedged, so that the force of the incoming water may not cause the cover to rise.

¹ Book IX. *pref.* 6.

² *tempus*, 'the temple of the head.' Cf. Greek, *κρόταφος βιβλίου τὸ ὑπισθεν μέρος*, Suidas. The illustrations were put together at the end of the whole work, Sackur, 14.

³ This chapter is translated by Schmidt, *Hero Alex.* I. 494.

⁴ *Hero Alex. Pneum.* I. 28; Schmidt, *ill.* p. 133.

- fistula, quae tuba dicitur, coagmentata in altitudine fit erecta. Modioli autem habent infra nares inferiores fistularum asses interpositos supra foramina
 3 eorum, quae sunt in fundis. Ita de supernis in modiolis emboli masculi torno politi et oleo subacti conclusique regulis et vectibus conmoluntur.¹ Qui erit aer ibi cum aqua, assibus obturantibus² foramina cogent. Extrudent inflando pressionibus per fistularum nares aquam in catinum, e quo recipiens paenula spiritu³ exprimit per fistulam in altitudinem, et ita ex inferiore⁴ loco castello conlocato ad saliendum aqua subministratur.
- 4 Nec tamen haec sola ratio Ctesibii fertur exquisita, sed etiam plures et variis generibus ab eo liquore pressionibus coactae spiritus efferre ab natura mutuatos effectus ostendentur, uti merularum⁵ aquae motu voces atque *angubatae*, bibentiaque et eadem moventia⁶ sigilla ceteraque, quae delectationibus oculorum et aurium usu sensus eblandiantur.
- 5 E quibus quae maxime utilia et necessaria iudicavi selegi, et in priore volumine de horologiis, in hoc de expressionibus aquae dicendum putavi. Reliqua, quae non sunt ad necessitatem sed ad deliciarum voluntatem, qui cupidiores erunt eius subtilitatis, ex ipsius Ctesibii⁷ commentariis poterunt invenire.

¹ conmoluntur *e*: conmoluntur *H*.

² obdurantibus *H*.

³ spiritu *Perr*: spiritus *H*.

⁴ inferiore *Joc*: inferiore *H*.

⁵ merularum (aquae) *Turn*: merulerūque *H*.

⁶ moventia *Mar* (*intr. Liv*): movent ea *H*.

⁷ ethesibi *H*.

¹ Hero Alex. (Schmidt) I. 91.

On the cover a pipe, which is called a trumpet, is jointed to it, and made vertical. The cylinders have, below the lower mouths of the pipes, valves inserted above the openings in their bases. 3. Pistons are now inserted from above rounded on the lathe, and well oiled. Being thus enclosed in the cylinders, they are worked with piston rods and levers. The air and water in the cylinders, since the valves close the lower openings, the pistons drive onwards. By such inflation and the consequent pressure they force the water through the orifices of the pipes into the vessel. The funnel receives the water and forces it out by pneumatic pressure through a pipe. A reservoir is provided, and in this way water is supplied from below for fountains.

4. Nor is this the only remarkable device of Ctesibius which is current. There are many others of various kinds which are driven by the pressure of water. The pneumatic pressure will be shown to produce effects borrowed from nature, both notes of blackbirds¹ by the motion of water, and walking automata²; little figures which drink and move; and other things which flatter the pleasure of the eyes and the use of the ears. 5. Of these I have chosen those which I have judged most useful and serviceable. In the last book I spoke about clocks; in this we have had to deal with water-pumps. The other things which are not for service, but for the purpose of our delight, can be found in the commentaries of Ctesibius by those who have a special wish for such ingenuity.

¹ Some such contrivance whereby the movement of an owl causes the blackbird to sing or be silent is described, *ib.*

- 1 DE hydraulicis autem, quas habeant ratiocinationes, quam brevissime proximeque attingere potero et scriptura consequi, non praetermittam. De materia compacta basi, ara¹ in ea ex aere fabricata conlocatur. Supra basim eriguntur regulae dextra ac sinistra scalarum forma compactae, quibus includuntur aerei modiolus,² fundulis ambulatilibus ex torno subtiliter subactis habentibus fixos in medio ferreos ancones³ et verticulis cum vectibus coniunctos, pellibusque lanatis involutis.⁴ Item in summa planitia foramina circiter digitorum ternum. Quibus foraminibus proxime in verticulis conlocati aerei delphini⁵ pendentia habent catenis cymbala⁶ ex ore infra foramina modiorum⁷ calata.
- 2 Intra aram, quod loci aqua sustinetur, inest pnigeus⁸ uti infundibulum inversum, quem subter⁹ taxilli alti circiter digitorum ternum suppositi librant spatium imum una inter labra pnigeos¹⁰ et arae fundum. Supra autem cervicula eius coagmentata arcu sustinet caput machinae, qui¹¹ graece *canon musicus* appellatur. In cuius longitudine canales,¹² si tetrachordos est, fiunt quattuor, si hexachordos, sex, si octochordos, octo.

¹ ara *Turnebus* : aerea *H.* ² modiolus *ed.* : moduli *H.*

³ angones *H.* ⁴ involutis *Mar* : -tos *H.*

⁵ dulpini *H.* ⁶ cymbala *Joc* : -li *H.*

⁷ modiorum *Joc* : modiorum *H.*

⁸ pnigeus *Turn* : inid genus *H.*

⁹ subter *Joc* : sup *H.* ¹⁰ pnigeos *Turn* : phiga eos *H.*

¹¹ qui *Ro* : quae *H.* ¹² canales, si *Joc* : sicanales *H.*

¹ Aristocles, a younger contemporary of Vitruvius, compares the water organ to a clepsydra, *Athen.* IV. 174c.

CHAPTER VIII

ON WATER ORGANS

1. ON the principles of water organs,¹ I cannot omit to touch as briefly and precisely as possible, and commit them to writing.² A base is made of framed wood and a bronze vessel is placed upon it. On the base, uprights are set up right and left, with rungs like a ladder. Between these, bronze cylinders are enclosed. Pistons which move up and down are accurately wrought on a lathe, and with iron piston rods fixed in the middle. These rods are joined by pins to the levers, and the pistons are covered with leather and wool. Further, on the top surface of the cylinders are openings about three fingers ($2\frac{1}{2}$ in.) broad. Adjoining the openings and placed on pins are bronze dolphins with valves hanging by chains from their mouths and secured below the openings of the cylinders.

2. Within the chest where the water is stored there is an air-vessel, like a funnel inverted; beneath this, small blocks about three inches high are placed, and they keep even the lowest space between the lips of the air-vessel and the bottom of the chest. On the neck of the air-vessel a small box is constructed which carries the top of the instrument, which is called in Greek the *canon musicus*. Along this there are four channels, if the instrument is tetrachord; six if it is hexachord; eight if it is octochord.

¹ Schmidt, *op. cit.*, Vol. I. pp. 496-505, translates this chapter and gives two illustrations. Plate B is based upon the text with the help of Barbaro and Schmidt.

- 3 Singulis autem canalibus singula epitonia sunt inclusa, manubriis ferreis conlocata. Quae manubria, cum torquentur, ex arca patefaciunt nares in canales. Ex canalibus autem canon habet ordinata in transverso foramina respondentia naribus, quae sunt in tabula summa, quae tabula graece *pinax* dicitur. Inter tabulam et canona regulae sunt interpositae ad eundem modum foratae et¹ oleo subactae, ut faciliter inpellantur et rursus introrsus reducantur, quae obturant ea foramina plinthidesque appellantur. Quarum itus et reditus alias obturat
- 4 alias aperit² terebrationes. Haec regulae habent ferrea choragia fixa et iuncta cum pinnis, quarum pinnarum tactus motiones efficit regularum continenter. Supra tabulam foramina quae ex canalibus habent egressum spiritus. Sunt anuli adglutinati, quibus lingulae omnium includuntur organorum. E modiolis autem fistulae sunt continentes coniunctae pnigeos³ cervicibus pertinentesque ad nares, quae sunt in arcula. In quibus asses sunt ex torno subacti et ibi conlocati, qui, cum recipit arcula animam, spiritum non patientur⁴ obturantes foramina rursus redire.
- 5 Ita cum vectes extolluntur, ancones deducunt⁵ fundos modiolorum ad imum delphinique, qui sunt in verticulis inclusi, calantes in eos cymbala, aere⁶ implent spatia modiolorum, atque ancones extollentes fundos intra modiolos vehementi pulsus crebritate et obturantes foramina cymbalis superiora, aera, qui est ibi clusus,⁷ pressionibus coactum in fistulas

¹ et oleo *Joc* : ex oleo *H*.² aperit *Joc* : operit *H*.³ pnigeos *Turn* : ligneis *H*.⁴ patientur *ed* : patietur *H*.⁵ deducunt *Joc* : deducunt *H*.⁶ cymbala, aere *Rode* : cymbaliare *H*.

3. In the several channels are single stopcocks fitted with an iron handle. When the iron handle is turned, it opens an aperture from the chest into the channels. The canon has openings from the channels; and the openings are placed along the canon corresponding to the openings in the top board which, in Greek, is called the *pinax*. Between the pinax above and the canon below, bars are fixed with openings corresponding to those of the canon and the pinax. The bars are well oiled so that they easily pass backwards and forwards, closing and opening the holes in the channels. The bars are called *plinthides*.

4. To these plinthides, iron springs are attached which connect with the keys of the organ, so that to touch the keys forthwith moves the plinthides. On the pinax, rings are fixed round the holes which allow the passage of the air from the channels. And these rings receive the feet of the organ pipes. Now from the cylinders, there run lengths of piping to the neck of the air-vessel and communicate with the openings in the chest. Over these openings there are placed valves wrought on the lathe. These valves, when the chest is supplied with air, close the openings and do not allow the air to escape.

5. Thus when the levers are raised, the piston rods draw down the pistons towards the bottom of the cylinder, and the dolphins working on pivots, releasing the valves in the cylinders, fill the cavity of the cylinders with air. Thereupon the piston rods raise the pistons within the cylinders with rapid and violent strokes and close the openings above, with the valves; the air in the cylinders is forced by the pumping into

⁷ *clusus H (cludentes Manil).*

cogunt, per quas in pnigea¹ concurrit et per eius cervices in arcam. Motione vero vectium vehementiore² spiritus frequens compressus epitoniorum 6 aperturis influit et replet animae canales. Itaque cum pinnae manibus tactae propellunt et reducunt continenter regulas alternis opturando³ foramina alternis aperiundo, e musicis artibus multiplicibus modulorum varietatibus sonantes excitant voces.

Quantum potui niti, ut obscura res per scripturam dilucide⁴ pronuntiaretur, contendi, sed haec non est facilis ratio neque omnibus expedita ad intellegendum praeter eos, qui in his generibus habent exercitationem. Quodsi qui parum intellexerit ex scriptis, cum ipsam rem cognoscet, profecto inveniet curiose et subtiliter omnia ordinata.

IX

1 TRANSFERTUR nunc cogitatio scripturae ad rationem non inutilem sed summa sollertia a maioribus traditam, qua in via raeda sedentes vel mari navigantes scire possimus, quot milia numero itineris fecerimus. Hoc autem erit sic. Rotae, quae erunt in raeda, sint latae per medium diametrum pedum quaternum [et sextantes],⁵ ut, cum finitum locum

¹ pnigea *Turn* : lignea *H.*

² vehementiore *Joc* : -res *H.*

³ obturando *Phil* : opturant *H.*

⁴ delucide *H.*

⁵ *del. Perrault, sed vide infra ix. 5.*

¹ The organist was called *hydraules*, Petron. 36.

² The diagram only shows one range of pipes, sometimes other rows were added with different intonation.

the pipes. Through these it rushes into the air-vessel and by the neck into the chest. By a stronger motion of the levers, the air is further compressed, flows in by the openings of the stopcocks and fills the channels with air. 6. Therefore when the keys are touched by the hands, they forthwith move the sliding bars backwards and forwards, closing some holes and opening others. By the art of music,¹ the notes of the organ are struck with manifold² and varied modulation.

I have striven to the best of my ability to describe clearly in writing a complicated machine. The task is not an easy one, nor accessible to the general understanding, except for those who have experience in matters of this kind. Yet if anyone grasps them imperfectly from my writings, a knowledge of the instrument will disclose the ingenuity and precision of its design.³

CHAPTER IX

ON MEASURING A JOURNEY

1. OUR next specification concerns a contrivance not without its uses, which we owe to the great skill of our predecessors. By this contrivance, whether we travel on land in a four-wheeled carriage, or by sea in a ship, we can learn how many miles we have covered. It is as follows. The wheels of the carriage are to be 4 feet in diameter, and on one

¹ From the reference of Tertullian, *de baptismo* 8, the organ would seem to have been known to the Christian Church. In 1931 an organ dated A.D. 288 was found at Aquincum near Buda-Pesth with bronze manual. *Observer*, May 24, 1931.

habeat in se rota ab eoque incipiat progrediens in solo viae facere versationem, perveniendo ad eam finitionem, a qua coeperit versari, certum modum spatii habeat peractum pedes XII s.

- 2 His ita praeparatis tunc in rotae modiollo ad partem interiorē¹ tympanum stabiliter includatur habens extra frontem suae rutundationis extantem denticulum unum. Insuper autem ad capsum raedae loculamentum firmiter figatur habens tympanum versatile² in cultro conlocatum et in axiculo conclusum, in cuius tympani frontem denticuli perficiantur aequaliter divisi numero quadringenti convenientes denticulos tympani inferioris. Praeterea superiori tympano ad latus figatur alter denticulus prominens extra dentes.
- 3 Super autem, planum eadem ratione dentatum inclusum in alterum loculamentum conlocetur, convenientibus dentibus denticulo, qui in secundi tympani latere fuerit fixus, in eoque tympano foramina fiant, quantum diurni³ itineris miliariorum numero cum raeda possit exire.⁴ Minus plusve rem nihil inpedit. Et in his foraminibus omnibus calculi rotundi conlocentur, inque eius tympani theca, sive id loculamentum est, fiat foramen unum habens canaliculum, qua calculi, qui in eo tympano inpositi fuerint, cum ad eum locum venerint, in raedae capsum et vas aeneum, quod erit suppositum, singuli cadere possint. Ita cum rota progrediens secum agat tympanum imum et denticulum eius singulis versationibus tympani superioris denticulos impulsu

¹ interiorē *Joc* : inferiorē *H*.

² versatile *ed* : -lem *H*.

³ diurni *ed Fl* : diuturni *H*.

⁴ exire = praeterire, *cf. Sen. Tac.*

wheel a point is to be marked. When the wheel begins to move forward from this point and to revolve on the road surface, it will have completed a distance of $12\frac{1}{2}$ feet¹ on arriving at the point from which it began its revolution.

2. As the next step, let a drum be secured to the inner side of the hub of the wheel with one tooth projecting from its exterior circumference. Above this, in the body of the carriage, let a box be securely fixed with a drum revolving perpendicularly, and fastened to an axle. On the outside edge of the drum 400 teeth are to be set at equal intervals so as to meet the teeth on the lower drum. Further, at the side of the upper drum there is to be fixed a second tooth projecting beyond the other teeth.

3. Now above there is to be placed a horizontal wheel toothed in the same manner, and enclosed in a similar case, with teeth which fit upon the single tooth which projects on the side of the second drum. In this drum openings are to be made equal in number to the miles which can be covered with the carriage in a day: whether the miles are more or less makes no difficulty. In all these openings, round stones are to be placed, and in the lining of the drum there is to be one opening attached to a small channel, where the stones placed in the drum when they come to the corresponding place can fall one by one into the carriage body and a bronze vessel which is placed below. 4. Thus when the wheel moves forwards and carries with it the lowest drum, in a single revolution, the wheel causes its one tooth to strike in passing the teeth in the upper drum. The effect

¹ Very near the value of π : $\frac{25}{8} = 3.125$. The value $\frac{22}{7} = 3.14 \dots$ was known to Archimedes and probably earlier.

cogat praeterire, efficiet, <ut,>¹ cum cccc² inum versatum fuerit, superius tympanum semel circumagatur³ et denticulus, qui est ad latus eius fixus, unum denticulum tympani plani producat. Cum ergo cccc versationibus imi tympani semel⁴ superius versabitur, progressus efficiet spatia pedum milia quinque, id est passus mille. Ex eo quot calculi deciderint, sonando singula milia exisse monebunt. Numerus vero calculorum ex imo⁵ collectus summa diurni <itineris>⁶ miliariorum numerum indicabit.

- 5 Navigationibus vero similiter paucis rebus commutatis eadem ratione efficiuntur. Namque traicitur per latera parietum axis habens extra navem prominentia capita, in quae includuntur rotae diametro pedum quaternum et s⁷ extantes habentes circa frontes adfixas pinnas aquam tangentes. Item medius axis in media navi <habet>⁸ tympanum cum uno denticulo extanti extra suam rutunditatem. Ad eum locum conlocatur loculamentum habens inclusum in se tympanum, peraequatis dentibus cccc convenientibus denticulo tympani, quod est in axe inclusum, praeterea ad latus adfixum extantem
- 6 extra rotunditatem alterum dentem unum. Insuper in altero loculamento cum eo confixo inclusum tympanum planum ad eundem modum dentatum, quibus dentibus <convenit>⁹ denticulus, qui est ad latus fixus tympano, quod est in cultro conlocatum, ut eos¹⁰ dentes, qui sunt plani tympani, singulis

¹ *add. Joc.* ² *cccc rec: ecce H.*

³ *circumagatur Joc: -gitur H.*

⁴ *semel rec: simul H.*

⁵ *imo e₂ ed: uno H.* ⁶ *add. Ro.*

⁷ *et s extantes Gr: & sextantae H.*

⁸ *add. Joc.* ⁹ *add. Kr.*

will be that when the lower drum has revolved 400 times, the upper drum will revolve once; and the tooth fixed on the side of the upper drum moves one tooth of the horizontal drum. Since, therefore, in 400 revolutions of the lower drum, the upper drum will revolve once, as it moves it will record thereby a distance of 5000 feet, that is, of 1000 paces. Hence when a stone falls, it will announce by its sound the traversing of a single mile, and the number of the stones collected from below will indicate, by their total, the number of miles for the day's journey.

5. With a few changes, a similar procedure is adopted for sea voyages. For an axle is passed through the sides of the hull, with ends projecting beyond the ship. On these axles are projecting wheels with diameters of $4\frac{1}{2}$ ¹ feet, having paddles round the edge which touch the water. Also the middle of the axle in the middle of the ship has a drum with one tooth projecting beyond its circumference. At this place a case is fixed with a drum enclosed within, having 400 teeth at equal intervals corresponding to the teeth of the drum which is fixed on the axle. In addition, another single tooth is fixed to the side of the drum and projects beyond it. 6. Above, and adjoining it, another case is fixed, which contains a horizontal wheel toothed in the same way. Answering to these teeth, there is the tooth which is fixed on the side of the vertical drum. This tooth at each revolution drives one of the teeth which belong to the

¹ Barbaro, *ad loc.*, suggests that the diameter was increased to allow for the drag of the water or wind.

¹⁰ (ita) ut eos *Schn* : in eos *H*.

versationibus singulos dens¹ inpellendo in orbem planum² tympanum verset. In plano autem tympano foramina fiant, in quibus foraminibus conlocabuntur calculi rotundi. In theca eius tympani, sive loculamentum est, unum foramen excavetur habens canaliculum, qua calculus liberatus ab obstantia cum ceciderit in vas aereum, sonitum significet.

- 7 Ita navis cum habuerit impetum aut remorum aut ventorum flatu, pinnae, quae erunt in rotis, tangentes aquam adversam vehementi retrorsus impulsu coactae versabunt rotas; eae autem involvendo se agent axem, axis vero tympanum, cuius dens circumactus singulis versationibus singulos secundi tympani dentes inpellendo modicas efficit circuitiones. Ita cum cccc ab pinnis rotae fuerint versatae, semel tympanum circumactum inpellet dente, qui est ad latus fixus, plani tympani dentem. Igitur circuitio tympani plani quotienscumque ad foramen perducet calculos, emittet per canaliculum. Ita et sonitu et numero indicabit miliaria spatia navigationis.

Quae pacatis et sine metu temporibus ad utilitatem et delectationem paranda, quemadmodum debeant fieri, peregi esse futurum.³

¹ dens *Ro*: dentes *H*.

² planum *Joc*: plenum *H*.

³ peregi esse futurum *H*: esse futurum *epezeget. Gr*: *del. Ro* (*cf. IX., pref. 16*).

horizontal drum and turns the horizontal drum round in a circle. Now in the horizontal drum, openings are to be made in which round stones are to be placed. One of these openings is to have a small channel adjoining it. Here when a stone can move without hindrance, it falls into the bronze vessel and announces this by a sound.

7. When, therefore, the ship receives an impulse from the force of the oars or the sails, the paddles fixed to the wheels touch the water which meets them, and being urged by a strong backward impulse, turn the wheels. These in turn move the axle by their revolutions; and the axle moves the drum, the tooth of which being driven round, strikes at each revolution a single tooth of the second drum, and produces the corresponding rotations. Thus when the wheels have been made to revolve 400 times by the paddles, the drum being once driven round will strike by the tooth placed on its side, a tooth in the horizontal drum. Therefore as often as the revolution of the horizontal drum brings the stones to the opening, it will let them drop through the small channel. And in this way, by the sound and number of the stones, it will indicate the miles traversed by the ship.

I have thus contrived the execution in proper form of the machines which may be carried out for useful purposes or for amusement in times of peace and tranquillity.¹

¹ This passage could only have been written when the empire was in a settled state, and completes the programme outlined in the preface to the whole work. The sequel resumes the military studies with which Vitruvius' career began.

X

- 1 NUNC vero quae ad praesidia periculi et necessitatem salutis sunt inventa, id est scorpionum et ballistarum rationes, quibus symmetriis comparari possint, exponam.

- Omnes proportionum eorum organorum ratiocinatorum ex ¹proposita sagittae longitudine, quam id organum mittere debet, eiusque nonae partis fit foraminis in capitulis magnitudo, per quae ²tenduntur nervi torti, qui bracchia continere ipsūm ²tamen debent. Eorum foraminum capituli deformatur altitudo et latitudo. Tabulae, quae sunt in summo et in imo capituli, peritreta ³ quae vocantur, fiant crassitudine unius foraminis, latitudine ⁴ unius et eius dodrantis, in extremis foraminis unius et eius <s>. Parastaticae ⁵ dextra ac sinistra praeter cardines altae foraminum IIII, crassae foraminum quinum; cardinis foraminis dimidi. A parastatica ad foramen spatium foraminis s̄q̄, a foramine ad medianam parastaticam item foraminis s̄q̄. Latitudo parastados mediae ⁶ unius foraminis et eius τκ, crassitudo foraminis unius.
- 3 Intervallum, ubi sagitta conlocatur in media parastade, foraminis partis quartae. Anguli quat-

¹ ex *Joc*: & *H*.

² quae *ed*: quas *H*.

³ peritreta *Voss ex Herone*: operae reliq; *H*.

⁴ latitudine *G*: *om. H*.

⁵ foraminibus unius et eius parastaticae *H*.

⁶ medius *H*.

¹ *scorpio* is used here generally for a catapult; its specific meaning is that of a smaller machine worked by a single individual, Book X. i. 3. *Caes. B.G. VII. 25. 2.*

CHAPTER X

ON CATAPULTS

1. WE now turn to the inventions which serve both to protect against danger and to satisfy the needs of safety; I will set forth the construction of scorpions¹ and balistae with the proportions on which they are based.

All the dimensions² of the machines as designed are given from the proposed length of the arrow which the machine is to let fly. The ninth part of this gives the size of the opening in the frame. Through these openings twisted cords are stretched,³ which are to hold back the arms of the catapults themselves.

2. The height and breadth of the frame are fixed by the size of the holes. The cross-pieces at the top and bottom of the frame are called *peritreta*⁴ and are to be one hole thick, and one and three-quarters wide; at the ends, one and a half. The side-pieces right and left (without the tenons) 4 holes high and five-eighths thick; the tenons half a hole. The side-piece to the hole, half a hole; from the hole to the middle upright, also half a hole. The breadth of the middle upright one hole and a third, its thickness one hole.

3. The aperture where the arrow is placed in the middle upright is to be $\frac{1}{4}$ of a hole. The four corners

¹ A unit of measurement is taken for military engines in the same way as for the orders of architecture. Hero, *Math. Gr.* 142. Vitruvius specifies the timber required by reference to this unit. Plate S.

² The cords are wound as tightly as possible round the nuts above and below the cross-pieces. The arm passes between the cords and still further stretches them.

⁴ *peritreta*. Hero, *Math. Gr.* 132 (Voss).

tuor, qui sunt circa, in lateribus et frontibus lamnis ferreis aut stylis aereis et clavis configantur. Canaliculi, qui graece *syrinx*¹ dicitur, longitudo foraminum XVIII. Regularum, quas nonnulli bucculas appellant, quae dextra ac sinistra canalem figuntur, <longitudo>² foraminum XVIII, altitudo foraminis unius et crassitudo. Et adfiguntur regulae duae, in quas inditur sucula, habentes³ longitudinem foraminum trium, latitudinem dimidium foraminis. Crassitudo bucculae, quae adfigitur (vocitatur camillum seu, quemadmodum nonnulli, loculamentum) securiclati cardinibus fixa, foraminis 1, altitudo foraminis s—. Suculae longitudo foraminum ::, crassitudo suculae foraminis VIII.⁴

- 4 Epitoxidos longitudo foraminis s—,⁵ crassitudo :—. Item chelonii. Chelae, sive manucla dicitur,⁶ longitudo foraminum trium, latitudo et crassitudo s÷. Canalis fundi longitudo foraminis XVI, crassitudo foraminis ○, altitudo s÷.⁷ Columellae basis⁸ in solo foraminum VIII, latitudo in plinthide, in qua statuitur columella, foraminis s—, crassitudo rz, columellae longitudo ad cardinem foraminum XII, latitudo foraminis s÷, crassitudo ccq. Eius capreoli tres, quorum longitudo foraminum VIII, latitudo dimidium foraminis, crassitudo z. Cardinis longitudinis foraminis; columellae capitis longitudo isk; antefixa latitudo foraminis Δsq, crassitudo 1.

- 5 Posterior minor columna, quae graece dicitur

¹ *syrinx ex Herone, Turnebus: graece strix H.*

² *add. Mar.* ³ *habentes Phil: habens H.*

⁴ *crassitudo scutulae foraminum .VIII. H.*

⁵ *foraminum .s— H.*

⁶ *crassitudo :— item chelo. item geloni sive manucla d. H.*

⁷ *latitudo .s÷ H.* ⁸ *columella & basis H.*

which are on the sides and fronts are to be fixed with iron bands, or with bronze pins and nails. The length of the channel (which in Greek is called *syrinx*) is to be of 19 holes; of the strips (which some call cheeks) which are fixed right and left of the channel, the length is to be of 19 holes; their height and thickness, one hole. Two other strips into which the windlass¹ is put are fixed, having a length of three holes and a width of half a hole. The thickness of the frame which is attached (it is called a chamber or case) with dovetailed tenons is of one hole; the height, $\frac{7}{12}$ of a hole. The length of the windlass is 4 holes; the width, $\frac{3}{4}$.²

4. The hook (*epitoxis*) is $\frac{7}{12}$ of a hole long and $\frac{1}{4}$ thick. So also the socket-case. The trigger or handle, 3 holes long, $\frac{3}{4}$ wide and thick. The length³ of the bottom of the channel, 16 holes; its width one,⁴ and thickness $\frac{3}{4}$. The base of the column on the ground, 8 holes. The width of the column where it is fitted into the plinth, $\frac{3}{4}$; the thickness, $\frac{2}{3}$. The length of the column up to the tenon, 12 holes; $\frac{3}{4}$ of a hole wide; $\frac{5}{8}$ thick. The tenons are one hole long.⁵ The column has three stays 9 holes long; $\frac{1}{2}$ a hole wide; $\frac{2}{3}$ thick. The head of the column is $1\frac{1}{2}$ holes long. The width of the antefix is $1\frac{1}{2}$ holes, the thickness is one.

5. The smaller column at the back, which the

¹ The windlass is at the end of the pipe, and draws back the cord at the back of the arrow.

² I.e. $\frac{1}{12}$.

³ Vitruvius has given the scantling of the timber above as 19 holes. The channel itself is 3 holes less.

⁴ The symbol ○ seems to denote the foramen.

⁵ I have moved this sentence up, although its reference to both column and stays is clear.

antibasis,¹ foraminum VIII, latitudo foraminis SI, crassitudinis FZ. Subiecto foraminum XII, latitudinis et crassitudinis eiusdem, cuius minor columna illa. Supra minorem columnam chelonium, sive pulvinus dicitur, foraminum IIS, altitudinis IIS, latitudinis SI[—]. Cherolabae² sicularum foraminum II S[—], crassitudo foraminis sfi, latitudo IS. Transversariis cum cardinibus longitudo foraminum ○, latitudo IS et crassitudo. Bracchi longitudo [IS]³ foraminum VII, crassitudo ab radice foraminis FZ, in summo foraminis CCZ; curvaturae foraminis VIII. Haec his proportionibus aut adiectionibus aut detraktionibus comparantur. Nam si capitula⁴ altiora, quam erit latitudo, facta fuerint,⁵ quae anatonae dicuntur, de brachiis demetur, ut, quo mollior est tonus propter altitudinem capituli, brachii brevitates faciat plagam vehementiorem. <Si>⁶ minus altum capitulum fuerit, quod catatonum⁷ dicitur, propter vehementiam brachia paulo longiora constituentur, uti facile ducantur. Namque quemadmodum vectis, cum est longitudine pedum quinque, quod onus IIII⁸ hominibus extollit, id, qui⁹ est x, duobus elevat,¹⁰ eodem modo brachia, quo longiora sunt, mollius, quod breviora, durius ducuntur.

¹ ante basis H.

² cherolabae Kôchly: carchebi H.

³ del. Mar. ⁴ capitula e₂: -li H.

⁵ fuerint e₂ ed: fuerit H.

⁶ add. ed.

⁷ catatonum ed: catonum H.

⁸ quinque . . . IIII Kôchly: IIII . . . quinque H.

Greeks call *antibasis*,¹ is of 8 holes; the width, $1\frac{1}{2}$ holes; the thickness, $\frac{2}{3}$. The prop has a length of 12 holes; and the breadth and thickness of the smaller column. Above the smaller column is a socket-piece or cushion as it is called, $2\frac{1}{2}$ holes long, the same thickness and $\frac{3}{4}$ of a hole broad. The handles of the windlass are $2\frac{7}{12}$ holes long; the thickness, $\frac{2}{3}$; the breadth, $1\frac{1}{2}$. The length of the cross-pieces and tenons is . . . holes; the width and thickness, $1\frac{1}{2}$. The length of the arm² is 7 holes; its thickness at the bottom, $\frac{2}{3}$; and at the top, $\frac{1}{2}$ a hole: its curve amounts to $\frac{2}{3}$ of a hole. 6. These proportions are attained in the work by additions or subtractions. For if the frames are too high for the breadth and these are called *anatona* [or 'tightened up'], something must be taken from the arms; so that the tension being relaxed, because of the height of the frame, the shortness of the arm may make the stroke more powerful. Let the frame be not so high and this is called *catatonum*,³ the arms will be made somewhat longer more effective so as to be easily pulled down. For just as when a lever five feet long raises a load with four labourers, that same load is raised by two labourers when the lever is 10 feet long; so the longer arms are pulled down more easily, the shorter arms with more difficulty.

¹ Hero gives ἀντιστήρις.

² The arms pass through the cords and are united by a string in which the notch for the arrow was placed.

³ = less tight.

⁹ id, qui Kr: idque H.

¹⁰ x, duobus elevat Köchly: ex duobus elevatum H.

- 1 CATAPULTARUM rationes, e quibus membris ex portionibus conponantur, dixi. Ballistarum autem rationes variae sunt et differentes unius effectus causa comparatae. Aliae enim vectibus suculis, nonnullae polyspastis, aliae ergastis, quaedam etiam tympanorum torquentur rationibus. Sed tamen nulla ballista perficitur nisi ad propositam magnitudinem ponderis saxi, quod id organum mittere debet. Igitur de ratione earum non est omnibus expeditum, nisi qui geometricis rationibus numeros et multiplicationes habent notas.
- 2 Nam quae¹ fiunt in capitibus foramina, per quorum spatia contenduntur capillo maxime muliebri vel nervo funes, magnitudine ponderis lapidis, quem debet ea ballista mittere, ex ratione gravitatis proportionem sumuntur, quemadmodum catapultis de longitudinibus sagittarum. Itaque ut etiam qui geometricae² non noverunt, habeant³ expeditum, ne in periculo bellico cogitationibus detineantur, quae ipse faciundo certa cognovi quaeque ex parte accepta praeceptoribus, finita exponam, et quibus rebus Graecorum pensiones ad modulos habeant rationem,

¹ namq̃ H.

² geometricae *e*₂ (cf. nosse Graece Aug): -ce H.

³ habeant *ed*: habent H.

¹ *mittere* first means 'to let go.' The vernacular phrase *mitte*, 'chuck it,' is illuminating. Hence the solemn name of the mass, *missa*: 'the assemblage is dismissed, *ite*; *missa est*.'

² Euclid treats numbers geometrically, Books VII-X. It has been said of Newton that he could treat geometrically

CHAPTER XI

ON BALISTAE

1. I HAVE described the design of a catapult and the details which are combined in accordance with proportion. The design of the balista varies and its differences are adjusted for the purpose of a single effect. For some are worked by levers and windlasses, some by many pulleys, some by capstans, some by wheels. Yet all balistae are constructed with a view to the proposed amount of the weight of the stone which such a machine is to let fly.¹ Therefore only those craftsmen can deal with the design who are familiar with the geometrical² treatment of numbers and their multiples.

2. For the holes which are made in the frames (through the openings of which ropes are stretched, made especially of woman's hair or of the sinews of animals) are taken proportionately to the amount of the weight of the stone which the balista is to shoot, in accordance with gravity,³ just as in the case of catapults the *length of the arrows* furnishes the module. Therefore in order that persons who are ignorant of geometry may be equipped and may not be delayed by calculation amid the perils of war, I will specify in accordance with my own knowledge gained in practice and also in accordance with the instructions of my teachers. Further, I will set forth in detail the manner in which the Greek problems which other mathematicians could only solve by analysis of a numerical character.

¹ Specific gravity was discovered by Archimedes, Book IX., *pref.* 9 ff. The phrase 'centre of gravity,' *κέντρον βαρύους*, was known before his time. Gow, *Greek Maths.* 238.

ad eam ut etiam nostris ponderibus respondeant, tradam explicata.

- 3 Nam quae ballista duo pondo saxum mittere debet, foramen erit in eius capitulo digitorum v; si pondo iiii, digitorum sex, vi,¹ digitorum vii; decem pondo digitorum viii; viginti pondo digitorum x; xl pondo digitorum xii sk; lx pondo digitorum xiii et digiti octava parte; lxxx pondo digitorum xv; cxx pondo i pedis et sesquidigiti;² c et lx pedis i9;³ c et lxxx pes et digiti v;⁴ cc pondo pedis⁵ et digitorum vi; cc et x pedis⁵ et digitorum vi; ccclx, pedis i s.

- 4 Cum ergo foraminis magnitudo fuerit instituta, describatur scutula, quae graece *peritretos* appellatur, cuius longitudo foraminum viii,⁶ latitudo duo et sextae partis. Dividatur medium lineae discriptae⁷ et, cum divisum erit, contrahantur⁸ extremae partes eius formae, ut obliquam deformationem habeat longitudinis sexta parte, latitudinis, ubi est versura, quartam partem. In qua parte autem est curvatura, in quibus procurrunt cacumina angulorum, et foramina convertuntur, et contractura latitudinis redeat⁹ introrsus sexta parte, foramen autem oblongius sit tanto, quantam epizygis¹⁰ habet crassitudinem. Cum deformatum fuerit, circum dividatur, extremam ut habeat curvaturam molliter circumactam.

- 5 Crassitudo eius foraminis si constituitur. Modioli

¹ vi Gr: et H.

² pondo is et sesq. H.

³ pedis i9 Kr: c et lx pedes ii H.

⁴ (c et lxxx) pes & et digiti GJ H.

⁵ pedes H.

⁶ viii Gr: vel H.

⁷ discripta H S.

⁸ contrahatur H.

⁹ redeant H.

¹⁰ epizygis Joc: opytigis H S.

weights are related to the modules, so that their relation may correspond to our weights.¹

3. For when a balista is to shoot a stone weighing two pounds, the aperture in the frame will be 5 digits; with four pounds, 6 digits; with <six> pounds, 7 digits; with ten pounds, 8 digits; with twenty pounds, 10 digits; with 40 pounds, $12\frac{1}{2}$ ² digits; with 60 pounds, $13\frac{1}{8}$ digits; with 80 pounds, 15 digits; with 120 pounds, one foot and $1\frac{1}{2}$ digits; with 160 pounds, one foot and 4 digits; with 180 pounds, one foot 5 digits; with 200 pounds, one foot 6 digits; with 210 pounds, one foot 6 digits; with 360 pounds, $1\frac{1}{2}$ feet.

4. When, therefore, the size of the hole is determined (as the module), let the cross-piece, *scutula*,³ which in Greek is called *peritretos*, be drawn; its length 8 holes; the breadth is to be $2\frac{1}{3}$ holes. The cross-piece when drawn is to be divided along the middle of the line, and when the middle is divided, the ends of the figure are to be contracted, so that it is bent obliquely to the extent of $\frac{1}{8}$ the length, and $\frac{1}{4}$ the breadth where the rope turns. The holes are to be made on the side of the curved part where the points of the angles converge; and the angles formed by contraction of the breadth are to turn $\frac{1}{6}$ inwards: the hole is to be longer than it is broad by the thickness of the bolt. When the frame is complete, it is to be dressed round so that it has the end of the curvature trimmed off.

5. The thickness of the frame is to be $\frac{9}{16}$ of a hole.

¹ The text is difficult to interpret owing to the notations employed. Plate S attempts to show the general design.

² SK = *semisquæ*.

³ *scutula* in the balista corresponds to *tabula* in catapult, c. x. 2.

foraminum duo, latitudo ισ , crassitudo praeterquam quod in foramine inditur foraminis s r , ad extremum autem latitudo foraminis π- . Parastatarum¹ longitudo foraminis vsf ; curvatura foraminis pars dimidia; crassitudo foraminis cc et partis Lx . Adicitur autem ad mediam latitudinem, quantum est prope foramen factum in descriptione, latitudine et crassitudine foraminis v , altitudo parte III .

6 Regulae, quae est in mensa, longitudo foraminum VIII ; latitudo et crassitudo dimidium foraminis. Cardines πz , crassitudo foraminis ιγ . Curvatura regulae r-Çk . Exterioris regulae latitudo et crassitudo tantundem; longitudo, quam dederit ipsa versura deformationis et parastaticae latitudo ad suam² curvaturam κ . Superiores autem regulae aequales erunt inferioribus κ . Mensae transversarii foraminis ccc κ .

7 Climacidos scapi longitudo foraminum XIII , crassitudo ικ , intervallum medium latitudo foraminis et³ parte quarta, crassitudo pars VIII κ . Climacidos superioris pars quae est proxima bracchiis, quae coniuncta est mensae, tota longitudine dividatur in partes v . Ex his dentur duae partes ei membro, quod Graeci *chelen*⁴ vocant \bigcirc latitudo r , crassitudo γ , longitudo foraminum III et semis κ ; extantia cheles foraminis s ; pterygomatos⁵ foraminis z et sicilicus.

¹ parastatorum *H.*

² & suam *H.*

³ et *Köchly*: ex *H.*

⁴ *χηλήν Turn*: chelon *H.*

⁵ pterygomatos *Turn*: plentigomatos *H.*

¹ The boxes were fitted into the cross-pieces above and below, and contained the iron pins round which the cords

Of the box¹ the length is 2 holes; the breadth $1\frac{3}{4}$; the thickness, in addition to the part which is inserted in the hole, $\frac{9}{16}$; while at the end the breadth is $2\frac{1}{16}$. The length of the side-posts is $5\frac{9}{16}$; the curvature, $\frac{1}{2}$ a hole; the thickness is. . . $\frac{3}{8}$. Now there is added to the middle of their breadth, *i.e.* its size near the hole in the drawing: in breadth and thickness $\frac{1}{8}$, the height $\frac{1}{4}$.

6. The length of the cheek (on either side of the table) is 8 holes; the breadth and thickness $\frac{1}{2}$ a hole. The tenons are to be $\frac{2}{3}$ long and $\frac{1}{4}$ in thickness. The curvature of the cheek is $\frac{3}{4}$. The breadth and thickness of the outside cheek is as much. The length is given by the angle of the design, and the breadth of the side-piece which is in curvature. Now the upper cheeks shall be equal to the lower cheeks: the cross-pieces of the table (in thickness) $\frac{3}{4}$.

7. The length of the shaft of the *ladder* is 13 holes, its thickness one hole. The breadth of the middle spaces is a hole and a quarter: the depth $1\frac{1}{8}$. The part of the upper ladder which is nearest to the arms and conjoined to the table is to have its total length divided into five parts.³ Two parts are to be given to that detail which the Greeks call *chēlē*; its breadth $1\frac{1}{16}$; its thickness $\frac{1}{4}$; its length $3\frac{1}{2}$ holes.⁴ The projection of the claw is $\frac{1}{2}$ a hole, of the wings $\frac{3}{16}$. The

were wound. They were of bronze: *infra* xii. 1. The dimensions of the boxes are measured by a 'hole' taken from the width of the cord.

¹ The thickness of the side-posts of the catapult is $\frac{1}{16}$, *supra* x. 2. These proportions are of the height of the side-posts, and are probably guides to the curvature.

² Of the remaining eight parts, three are above, and three below, the claw, which is two parts.

⁴ The reference of this is doubtful.

Quod autem est ad axona, quod appellatur frons transversarius, foraminum trium.

- 8 Interiorum regularum latitudo foraminis $\bar{\Gamma}$, crassitudo $\Xi\kappa$. Cheloni replum, quod est operimentum, securiculae includitur κ scapo¹ climacidos latitudo $\approx Q$, crassitudo foraminis² $\chi\iota\kappa$. Crassitudo quadrati, quod est ad climacida, foraminis Γc , in extremis κ , rutundi autem axis diametros aequaliter erit cheles, ad claviculas autem minus parte sexta decuma
9 κ . Anteridon longitudo foraminum $\mu\mu\mu$,³ latitudo in imo foraminis $\bar{\Gamma}$, in summo crassitudo $\Gamma\kappa$. Basis, quae appellatur *eschara*,⁴ longitudo foraminum:::, anti-basis⁵ foraminum $\mu\mu\mu$, utriusque crassitudo et latitudo foraminis $\ddot{\Gamma}$. Conpingitur autem dimidia altitudinis κ columna, latitudo et crassitudo ιs . Altitudo autem non habet foraminis proportionem,⁶ sed erit quod opus erit ad usum. Bracchii longitudo foraminum $\nu\iota$, crassitudo in radice foraminis, in extremis Γ .

De ballistis⁷ et catapultis symmetrias, quas maxime expeditas putavi, exposui. Quemadmodum autem contentionibus eae temperentur e nervo capilloque tortis rudentibus,⁸ quantum comprehendere scriptis potuero, non praetermittam.

¹ scapo *Gr*: scapos *H*.

² foraminum *H*.

³ $\mu\mu\mu$ *Gr*: eius *H*.

⁴ *eschara H*.

⁵ ante basis *H*.

part <from the claw> to the *axon* which <in Latin> is called the front cross-piece, is of 3 holes.

8. The breadth of the interior cheeks is $\frac{1}{4}$, the thickness $\frac{1}{8}$. The *replum*¹ or covering moulding of the claw is dovetailed into the shaft of the ladder with a breadth of $\frac{1}{8}$, and a thickness of $\frac{1}{12}$. The thickness of the square piece² on the ladder is $\frac{2}{3}$, at the ends one hole. The diameter of the round axle is equal to that of the claw, but at its pivots $\frac{1}{16}$ less. 9. The length of the supports is $4\frac{1}{2}$ holes, the breadth at the bottom $\frac{2}{3}$, at the top the thickness is $\frac{7}{12}$. The base, which is called *eschara*,³ is 4 holes long, the anti-basis⁴ 4 holes long; the breadth and thickness of both, half a hole. A stay is jointed on half-way up the column, with a breadth and thickness of $1\frac{1}{2}$ holes. The height has no proportion of modules but will be in accordance with requirements. The length of the arms is 6 holes, the thickness at the root one hole, at the ends $\frac{2}{3}$.

I have set forth the proportions which I thought most convenient for catapults and balistae. I will now describe the way in which they are controlled by tension, with ropes twisted of sinews and human hair, as far as I can comprise it in writing.

¹ Book IV. vi. 5. This guides the claw in its movement along the ladder.

² This contains the claw and has the replum attached to it.

³ Cf. *infra* xiv. 1.

⁴ A similar horizontal piece at right angles to the base.

⁶ proportione *H*.

⁷ De ballistas *H*.

⁸ rudentibus *rec* : rutudentibus *H*.

XII

- 1 SUMUNTUR tigna amplissima longitudine; supra figuntur chelonia,¹ in quibus cluduntur suculae. Per media autem spatia tignorum insecantur² exciduntur formae, in quibus excisionibus cluduntur capitula catapultarum, cuneisque distinentur,³ ne in contentionibus moveantur. Tum vero modioli aerei in ea capitula includuntur et in eos cuneoli ferrei, quas *epizygidas*⁴ Graeci vocant, conlocantur.
- 2 Deinde ansae rudentum induntur per foramina capitulorum, in alteram partem⁵ traiciuntur, deinde in suculas⁶ coiciuntur² involvuntur, uti vectibus per eas ext<enti>⁷ rudentes,⁸ cum manibus sunt tacti, aequalem in utroque sonitus habeant⁹ in responsum. Tunc autem cuneis ad foramina concluduntur, ut non possint se remittere. Ita traiecti in alteram partem eadem ratione vectibus per suculas extenduntur, donec aequaliter sonent. Ita cuneorum conclusionibus ad sonitum musicis auditionibus catapultae¹⁰ temperantur.

De his rebus quae potui dixi. Restat mihi de oppugnatoriis rebus, quemadmodum machinationibus et duces victores et civitates defensae esse possint.

¹ cheloniae H.

² *asyndeton ut in sermone iudiciali.*

³ distinentur H.

⁴ *ἐπισυγίδας* Turn: epysycidas H.

⁵ pari&e H. ⁶ suculas Joc: -lam H.

⁷ extenti rudentes Joc.

⁸ extrudentes H.

CHAPTER XII

ON THE PREPARATION OF CATAPULTS AND BALISTAE

1. <Two square> beams of considerable length are taken; sockets are fixed on them in which windlasses are enclosed. Now in the middle parts of the beams, rebates are cut and hollowed out. In these hollows, the frames of the catapults are fitted, and kept apart by wedges to prevent their moving when the ropes are stretched. Next, bronze boxes¹ are fitted into the frames, and iron pins are placed in them, which the Greeks call *epizygides*.

2. From these pins the ends of the ropes are passed through the holes of the frame and cross over to the other end. Thence they are taken and coiled round the windlass, so that when the ropes are stretched by the levers, and struck by hand, they may resound evenly on either side. Then they are secured by wedges at the holes so that they cannot become loose. Passing to the other end, they are stretched on the windlasses by the levers until they give an equal note.² So by the application of wedges, the catapults are tuned to the right note by a musical ear.

On these matters I have said what I could. It remains to me, as I deal with sieges,³ to explain the machinery by the help of which generals may gain victories, and cities be defended.

¹ This description completes the account of the boxes in the last chapter.

² Book I. i. 8.

³ *Oppugnatoria* is the Latin for *πολιορκητικά*.

⁹ *habeant Joc: habent H.*

¹⁰ *catapulta H.*

XIII

- 1 PRIMUM ad oppugnationis aries sic inventus memoratur esse. Carthaginienses ¹ ad Gadis oppugnandas castra posuerunt. Cum autem castellum ante cepissent, ² id demoliri ³ sunt conati. Posteaquam non habuerunt ad demolitionem ferramenta, sumpserunt tignum idque manibus sustinentes capiteque eius summum murum continenter pulsantes summos lapidum ordines deiciebant, et ita gradatim ex ordine totam communionem dissipaverunt.
- 2 Postea quidam faber Tyrius nomine Pephrasmenos hac ⁴ ratione et inventione inductus malo statuto ex eo alterum transversum uti trutinam suspendit et in reducendo et inpellendo vementibus ⁵ plagis deiecit Gaditanorum murum. Ceras ⁶ autem Carchedonius ⁷ de materia primum basim subiectis rotis fecit supraque compegit arrectariis et iugis varas et in his suspendit arietem coriisque bubulis textit, uti tutiores essent, qui in ea machinatione ad pulsandum murum essent conlocati. Id autem, quod tardos conatus habuerat,
- 3 testudinem arietariam appellare coepit. His tunc

¹ chartaginienses H. ² coepissent H.

³ demoliri H. ⁴ hac G: ac H S.

⁵ vementibus Lachm: venientibus H.

⁶ ceras Gr: caeteras H.

⁷ carchedonius Gr: chalchedonius H (Καρχηδόσιος Ath), cf. Carchedonius, Plaut. Poen. prol. 53.

¹ Vitruvius, as usual, begins with an historical sketch. He drew upon sources older than Athenaeus Mechanicus who was either later than or a contemporary of Vitruvius. The Marcellus to whom Ath. dedicates his work may well have been the nephew of Augustus. Hero and Philo Byzantius probably belong to the end of the first century A.D. The works of these three writers are given in *Mathematici Veteres*, Paris, 1693.

CHAPTER XIII

ON SIEGES

1. IN the first place, the invention¹ of the battering-ram for sieges is related in the following manner. The Carthaginians had pitched their camp for the siege of Cadiz. Having already captured a fort, they set about demolishing it. Since they lacked iron tools for this purpose, they took a beam, and raising it by manual labour, they swung the end repeatedly against the top of the wall and brought down the top courses of the masonry. Thus they broke up the whole fortification little by little and in order.

2. Subsequently a Tyrian engineer² named Pephrasmenos, following the method of this invention, set up a pole and from it suspended a cross-beam, like the beam of a balance. This he drew backward and thrust forward, and by its violent blows overthrew the walls of Cadiz. Ceras³ the Carthaginian first made a wooden platform⁴ with wheels underneath, upon which he constructed penthouses with uprights and cross-pieces. In these he suspended a ram which he protected with oxhides, for the greater safety of the mechanics who were posted there to attack the wall. The contrivance, because it moved slowly, he was the first to call the "ram tortoise." 3. After these first steps had been

² Athen. *Math. Vett.* 3 gives the name as *Pephrasmenos*.

³ Ceras occurs among the names of the families of the Nethinim who returned with Nehemiah: *LXX. I Esdras*, v. 29.

⁴ Athen. *Math. Vett.* 3.

primis gradibus positis ad id genus machinationis,¹ postea cum Philippus, Amyntae filius, Byzantios² oppugnaret, Polyidos³ Thettalos⁴ pluribus generibus et facilioribus explicavit, a quo receperunt doctrinam Diades et Charias,⁵ qui cum Alexandro militaverunt.

Itaque Diades scriptis suis ostendit se invenisse turres ambulatorias, quas etiam dissolutas in exercitu circumferre solebat, praeterea terebram et ascendentem machinam, qua ad murum plano pede transitus esse posset, etiam corvum demolitorem,⁴ quem nonnulli gruem appellant. Non minus utebatur ariete subrotato, cuius rationes scriptas reliquit. Turrem autem minimam ait oportere fieri ne minus altam cubitorum LX,⁶ latitudinem XVII, contracturam autem summam imae partis quintam, arrectaria in turris in imo dodrantalia, in summo semipedalia. Fieri autem ait oportere eam turrem tabulatorum⁷ 5 decem, singulis partibus in ea fenestratis.⁸ Maiorem vero turrem altam cubitorum CXX, latam cubitorum XXIII(s),⁹ contracturam¹⁰ item quinta parte, arrectaria pedalia in imo, in summo sedigitalia.¹¹ Hanc magnitudinem turris faciebat tabulatorum XX, cum haberent singula tabulata circumitionem cubitorum ternum. Tegebat autem coriis crudis, ut ab omni plaga essent tutae.

¹ machinationes *H S*.

² Byzantios *Ro* (Βυζαντίους *Ath*): byzantio *H*, bizantio *S G*.

³ pholydos *H*, pholidos *S G*.

⁴ thethalos *H S*, thetalos *G*.

⁵ carias *H*.

⁶ LX *Joc* (§ *Ath*): novem *H* = IX.

⁷ tabulatorum *ed. Fl*: tabularum *H*.

⁸ *Athen. περίπτερος*.

⁹ *add. ex Ath.*

¹⁰ contracturam *ed*: contra fracturam *H*.

taken towards this kind of machine, when Philip the son of Amyntas was besieging Byzantium, Polyidus a Thessalian made a variety of designs with easier construction; his method was continued by his pupils, Diades and Charias, who accompanied Alexander on his campaigns.¹

Diades, then, in his books ² shows that he invented Movable Towers, the parts of which he used to assemble and carry round with the army; in addition to this, the Borer and the Climbing Machine by which a passage from the level up the wall was possible; further, the Grappling-hook for demolition which some call the Crane. 4. Moreover, he used to employ a ram on wheels for which he left detailed descriptions. He says that the smallest tower should be 60 cubits high and 17 broad, and that it should be contracted at the top, by $\frac{1}{8}$ of the width at the foot. The uprights for the towers should be 9 inches at the bottom and 6 inches at the top. He says further that the tower should be ten stories high, with openings like windows on each side. 5. The largest tower is to be 120 cubits high, $23\frac{1}{2}$ wide, the contraction at the top $\frac{1}{8}$; the uprights one foot at the bottom, six inches at the top. He used to construct this size of tower with 20 stories, and the several stories had a balcony three cubits wide. These he further covered with raw hides to preserve them from attack.

¹ Athen. *loc. cit.*

² Athen. *op. cit.* pp. 4, 5, gives a summary closely corresponding to the rest of this chapter. Sackur *op. cit.* 64. Athenaeus interpolates phrases that are superfluous and sometimes display misunderstanding.

¹¹ *sedigitalia Ro (Ath): semipedalia H.*

6 Testudinis arietariae comparatio eadem ratione perficiebatur. Habuerat autem intervallum xxxii,¹ altitudinem praeter fastigium xvi, fastigii autem altitudo ab strato² ad summum cubita xvi.³ Exhibat autem in altum et supra medium tectum fastigium non minus cubita duo, et supra extollebatur turricula cubitorum quattuor, tabulatorum iii, quo⁴ tabulato summo statuebantur scorpionis et catapultae, inferioribus congerebatur aquae magna⁵ multitudo ad extinguendum, si qua⁶ vis ignis immitteretur. Constituebatur autem in eam arietaria⁷ machina, quae graece dicitur *criodocis*,⁸ in qua conlocabatur torus perfectus in torno, in quo insuper constitutus aries rudentium⁹ ductionibus et reductionibus efficiebat magnos operis effectus. Tegebatur autem is coriis crudis quemadmodum turris.

7 De terebra has explicuit scriptis rationes. Ipsam machinam uti testudinem in medio habentem conlocatum in orthostatis canalem, quemadmodum in catapultis aut ballistis fieri solet, longitudine cubitorum l, altitudine cubiti, in quo constituebatur transversa sucula. In capite autem dextra ac sinistra trocleae¹⁰ duae, per quas movebatur quod inerat in eo canali capite ferrato tignum. Sub eo autem in ipso canali inclusi tori¹¹ crebriter celeriores et vehementiores efficiebant eius motus. Supra

¹ xxxii *Sackur*: xxx *H.*

² ab strato *ed*: abstracto *H.*

³ xvi ($\overline{\text{v}}^{\text{v}}$ *Ath*): vii *H.*

⁴ iii. quo *Gr*: in quo *H.*

⁵ *magnae H.*

⁶ si qua *rec*: siq; *H.*

⁷ *varietaria H.*

⁸ *criodocis H.*

⁹ *rudentium Joc*: *prudentium H.*

¹⁰ *trocliae H.*

¹¹ *inclusi tori Laet*: *inclusit uti H.*

6. The construction of the Ram Tortoise was carried through with the same method. It had a breadth of 32 cubits, a height (not including the gable) of 16 cubits, and the height of the gable from the platform to the summit, of 16 cubits. Now the gable rose up above the middle of the roof not less than 2 cubits. Above this there was raised a small tower 4 cubits wide, of 3 stories;¹ in the top story of this there were placed scorpions and catapults,² in the lower stories a large quantity of water was stored to extinguish whatever flames should be kindled. Now there was constructed in the tortoise a machine for the ram, which in Greek is called *criodocis*. In this was fixed a roller finished on the lathe, on which the ram was placed, and being drawn forwards and backwards by ropes, produced great effects. This was covered with raw hides in the same way as the tower.

7. The method of constructing the Borer he described as follows: the machine itself was like the Tortoise, having, in the middle, a channel resting upon uprights (as is customary in catapults or balistas) 50 cubits long and a cubit high, on which there was placed a windlass crosswise. At the front were two pulleys, right and left, by which the beam with its iron front³ was moved along the channel. Under the beam in the channel itself rollers were fixed at frequent intervals and rendered its movements quicker and more violent. Above the beam

¹ Vitruvius' text is quite clear if we take *in* as *III*, from which it is almost indistinguishable.

² These were small machines for sharpshooting.

³ The Borer had a sharp iron point to pierce the wall, not to batter it down like the Ram. Athenaeus confuses the construction of the two, *op. cit.* 5.

autem ad tignum, quod inibi erat, arcus tegebantur ad canalem crebriter, uti sustinerent corium crudum, 8 quod ea machina erat involuta. De corace nihil putavit scribendum, quod animadverteret eam machinam nullam habere virtutem. De accessu, quae *epibathra* graece dicitur, et de marinis machinationibus, quae per navium aditus habere posset, scripsit tantum; pollicitum esse vehementer animadverti neque rationes eorum eum explicavisse.

Quae sunt a Diade¹ de machinis scripta, quibus sint comparationibus, exposui. Nunc quemadmodum a praeceptoribus accepi et² utilia mihi videntur, exponam.

XIV

- 1 TESTUDO, quae ad congestionem fossarum paratur (eaeque etiam accessus ad murum potest habere), sic erit facienda. Basis compingatur, quae graece *eschara*³ dicitur, quadrata habens quoque versus latera singula pedum XXI⁴ et transversaria IIII. Haec autem contineantur⁵ ab alteris duobus crassis is, latis s; distent autem transversaria inter se circiter pedes III s.⁶ Supponanturque in singulis intervallis eorum arbusculae, quae graece *anaxopodes*⁷ dicuntur,

¹ a Diade *Joc*: ademade *H*.

² accepi et *S^o G^o*: accipiet *H*. ³ *ἐσχάρα* *Joc*: *thera* *H*.

⁴ XXI *Kr* (*πῆχυν ἰδὲ Αἰῆ*): XXV *H*.

⁵ contineantur *Joc*: -atur *H*.

⁶ pedes III s *Kr* (*δύο πῆχεις καὶ παλαιστὴν ἓνα Αἰῆ*): pede & s *H*.

⁷ *anaxopodes* *H*.

¹ Arrian reports the use of the *epibathra* by Alexander, *Anab.* IV. 27. 1.

thus placed arches were placed frequently along the channel to hold up the raw hide with which the machine was enveloped. 8. Diades did not think it necessary to write about the Grappling-hook because he perceived that the machine had no value. Concerning the Climbing Machine, which in Greek is called *epibathra*,¹ and concerning the use, in naval engineering, of such a machine for boarding a ship, he just made mention. I noted especially that after making a promise he failed to explain their proportions.

I have set forth² the writings of Diades on the construction of machines. I will now set forth what I myself was taught, so far as it is of use.

CHAPTER XIV

ON THE TORTOISE FOR FILLING DITCHES

1. THE Tortoise which is applied to filling ditches³ (and it thus furnishes an approach to the wall of the besieged) is to be constructed as follows. Let the base, which in Greek is called *eschara*, be made square, having on each side a length of 21 feet, with four cross-pieces. Now these are to be held together by two others 18 inches thick, and 6 inches broad. Let the cross-pieces be at intervals of $3\frac{1}{2}$ feet. Timbers are to be fixed underneath in their several intervals (these are called *amaxopodes*⁴ in Greek),

¹ Sackur sees Byzantine influences in the extant text of this chapter, p. 121. But there is little trace of this influence in the MS. tradition, Vol. I. *pref.* xv. n.

² *χελώνη χωστρίς*, Diod. II. 27, *testudo . . . aequandi loci causa*, Caes. B.C. II. 2.

⁴ *Athen. op. cit.* 5.

in quibus versantur rotarum axes conclusi lamnis ferreis. Eaeque arbusculae ita sint temperatae, ut habeant cardines et foramina, quo vectes traiectiones earum expediant, uti ante et post et ad dextrum seu sinistrum latus, sive oblique ad angulos opus fuerit, ad id per arbusculas versatis progredi possint.

- 2 Conlocentur autem insuper basim tigna duo in utramque partem proiecta pedes senos, quorum circa projectiones figantur altera proiecta duo tigna ante frontes pedes XII,¹ crassa et lata uti in basi sunt scripta. Insuper hanc compactionem exigantur postes compactiles praeter cardines pedum VIII, crassitudine quoquoersus palmopedales, intervalla habentes inter se sesquipedes. Ea concludantur superne intercardinatis² trabibus. Supra trabes conlocentur capreoli cardinibus alius in alium³ conclusi, in altitudine excitati pedes VIII. Supra capreolos conlocetur quadratum tignum, quo capreoli
3 coniungantur. Ipsi autem laterariis circa fixis contineantur teganturque tabulis maxime prinis,⁴ si non, ex cetera materia, quae maxime habere potest virtutem, praeter pinum aut alnum; haec enim sunt fragilia et faciliter recipiunt ignem. Circum tabulata conlocentur crates⁵ ex tenuibus virgis creberrime textae⁶ maximeque recentibus. Percrudis coriis duplicibus consutis, fartis alga aut paleis in aceto maceratis, circa tegatur machina tota. Ita ab his reiciuntur plagae ballistarum et impetus incendiorum.

¹ XII (πῆχες ἡ Ἀθ): VII H.

² intercardinatis H S G^o: interordinatis G S^o.

³ alius an alium H.

⁴ prinis Gr: primis H.

⁵ crates S^o G^o: grates H.

⁶ textae rec: texta H.

in which the axles of the wheels turn, and are sheathed in iron plates. And these timbers are to be constructed with pivots and holes whereby levers are passed through and cause them to turn, so that the machines can move front or back, right or left, or sideways as may be necessary, by the turning of the wheels by help of the timbers.

2. Let two beams be laid on the base projecting 6 feet on either side, and on the projecting parts let there be fixed two other beams projecting in front 12 feet and with the thickness and breadth as described for the base. On this frame let there be put up frame-posts 9 feet high not including the tenons, 15 inches square and 18 inches apart. Let these be joined above by beams mortised together. Above the beams let there be fixed rafters locked in one another by tenons and rising to a height of 9 feet. Above the rafters is a squared ridge-piece by which they are to be joined together. 3. Further, they are to be held together by purlins and covered by planks; best if of holm-oak, otherwise of wood which is very strong, but not of pine or alder; for these are brittle and inflammable. Around the framework are to be placed wattles, closely interwoven, of thin twigs which are to be as green as possible. The whole machine is to be covered¹ with double oxhide very raw sewn together and filled in with sea-weed or straw which is soaked in vinegar. For by these expedients the shots of the balistae and the danger of fire will be repelled.²

¹ This expedient was used by the Tyrians during the siege by Alexander, Diod. XVII. 45.

² Sackur, *op. cit.*, pp. 67-75, gives an elaborate discussion with illustrations.

1 Est autem et aliud genus testudinis, quod reliqua omnia habet, quemadmodum quae supra scripta sunt, praeter capreolos, sed habet circa pluteum et pinnae ex tabulis et superne subgrundas proclinatas, supraque tabulis et coriis firmiter fixis continentur. Insuper vero argilla cum capillo subacta ad eam crassitudinem inducatur, ut ignis omnino non possit ei machinae nocere. Possunt autem, si opus fuerit, eae machinae ex viii rotis esse, sed ad loci naturam ita opus fuerit temperare. Quae autem testudines ad fodiendum comparantur (*orynges*¹ graece² dicuntur), cetera omnia habent, uti supra scriptum est, frontes vero earum fiunt quemadmodum anguli trigoniorum, uti a muro tela cum in eas mittantur, non planis frontibus excipiant plagas sed ab lateribus labentes, sine periculoque fodientes, qui intus sunt, intuentur.

2 Non mihi etiam videtur esse alienum de testudine, quam Hagetor³ Byzantius fecit, quibus rationibus sit facta, exponere. Fuerat enim eius baseos longitudo⁴ pedum lx, latitudo xiii. Arrectaria, quae supra compactionem erant quattuor conlocata, ex binis tignis fuerant compacta, in altitudinibus singulo pedum xxxvi, crassitudine palmopedali, latitudine sesquipedali. Basis eius habuerat rotas viii, quibus agebatur. Fuerat autem earum altitudo pedum vi s—, crassitudo pedum iii, ita fabricata triplici

¹ ὀρυγγες Gr (ex Hesych): origines H.

² graeci H S.

³ Hagetor Gr (Agetor Joc): hector H.

⁴ longitudo G: -dine H S.

CHAPTER XV

ON THE TORTOISE OF HAGETOR

1. THERE is also another kind of tortoise which has everything in the manner above described except the rafters. Instead it has a parapet and battlements made of boards with sloping eaves above; these are held together by boards and skins securely fixed. Over these clay kneaded with hair is applied to such a thickness that fire cannot damage the machine. If it is required, these machines can be on eight wheels; but it will be necessary to adjust them to the lie of the ground. Now the tortoises which are designed for digging (in Greek they are called *orynges*¹) follow the description in every respect but that their fronts are made like the angles of triangles, so that when arrows are shot against them from the walls the blows which they receive do not fall upon a plane surface, but slip along the sides, and the men within are protected² and dig without danger.

2. It now seems appropriate to explain the methods which Hagetor³ of Byzantium used for his tortoise.⁴ The length of the base was 60 feet, the breadth 13. The uprights which were set up on the frame, four in number, were each made of two timbers, of a height for each of 36 feet, and 15 inches broad with a thickness of 18 inches. The base had eight wheels on which it moved. The wheels had a height of 6 feet 9 inches, a thickness of 3 feet and were made of

¹ ὀρυγξ (Hesych. ὀρύγι) 'a tool, for digging.' It had a single edge like a hoe, *μουνόρυξαν ὀρυγα*, *Anth. Pal.* VI. 297.

² *intueor* in pass. sense, *Amm. Marc.* XXIII. 5. 13.

³ *Athen. op. cit.* 5.

⁴ Plate T.

materia: alternis se contra subsudibus¹ inter se coagmentatae lamnisque ferreis ex frigido ductis alligatae.

3 Eae in arbusculis, sive amaxopodes dicuntur, habuerant versationes. Ita supra transtrorum planitiem, quae supra basim fuerat, postes erant erecti pedes XVIII \div ,² latitudine s \div ,³ crassitudine rz, distantes inter se is \div . Supra eos trabes circumclusae continebant totam compactionem latae pede i \div , crassae s \div . Supra eam capreoli extollebantur altitudine pedum xii; supra capreolos tignum conlocatum coniungebat capreolorum compactiones. Item fixa habuerant lateraria in transverso, quibus insuper contabulatio circumdata contegebat inferiora.

4 Habuerat autem mediam contabulationem supra trabiculas, ubi scorpiones et catapultae conlocabantur. Et erigebantur arrectaria duo compacta pedum xxxv,⁴ crassitudine sesquipedali, latitudine PII, coniuncta capitibus transversario cardinato tigno et altero mediano inter duos scapos cardinato et lamnis ferreis religato. Quo insuper conlocata erat alternis materies inter scapos et transversarium traiecta e chelonis et anconibus⁵ firmiter inclusa. In ea materia fuerunt ex torno facti axiculi duo, e quibus funes alligati retinebant arietem.

5 Supra caput eorum, qui continebant arietem, conlocatum erat pluteum turriculae similitudine ornatum, uti sine periculo duo milites tuto stantes prospicere possent et renuntiare, quas res adversarii

¹ subsudibus *H.*

² XVIII *Joc* (δωδεκαπήχεις *Ath*): xxviii. *H S.*

³ latitudine (*Ro*) s \div *Joc* (παλαιστὰς γ *Ath*): latitudinis \div *H.*

⁴ xxxv (τριάκοντα πήχεις *Ath*): xxxv *H.*

⁵ anconibus *H.*

three layers of wood jointed together with alternating tenons and secured with plates of chilled iron.

3. They revolved in blocks (or as they are called *amaxopodes*). Above the cross-pieces of the floor which was above the base, posts were erected 18 feet high, 9 inches broad and 8 inches thick, and one foot 9 inches apart. Above the posts, beams one foot 9 inches wide and 9 inches thick were carried round and held the framing together. Above the framing struts¹ were raised with a height of 12 feet; above the struts a beam was fixed which received the joints of the struts. They had side-pieces placed obliquely on which boarding was carried to protect the lower parts.

4. The machine had in the middle aisle a floor upon joists, where the scorpions and catapults were placed. There were also set up two upright pieces jointed together, 45 feet high, 18 inches wide and 9 inches thick, joined at the top with a dovetailed cross-piece, and a second half-way up, mortised between the two uprights and secured with iron plates. Above this, between the uprights and the cross-piece, a wooden frame was placed consisting of blocks and firmly held by clamps. In this frame two axles turned on the lathe were placed, and the ram was controlled by ropes attached to the axles.

5. Above the heads of those who worked the ram, a shelter was placed built after the fashion of a turret, so that the two soldiers standing in safety could look out and report the movements of the enemy.

¹ These struts probably ran out from the base, were united by the beam and tied to the uprights of the frame by the sloping side-pieces.

conarentur. Aries autem eius habuerat longitudinem pedum *civ*, latitudine in imo palmopedali, crassitudine pedali, contractum capite in latitudine¹ pes, crassitudine *s*~.

- 6 Is autem aries habuerat de ferro duro rostrum, ita uti naves longae solent habere, et ex ipso rostro lamminae ferreae *iiii* circiter pedum *xv* fixae fuerant in materia. A capite autem ad imam calcem tigni contenti fuerunt funes *iii*² crassitudine digitorum *viii*, ita religati, quemadmodum navis a puppi ad proram continentur, eique funes praecinctura e transversis erant religati habentes inter se palmipedalia spatia. Insuper coriis crudis totus aries erat involutus. Ex quibus autem funibus pendeat,³ eorum capita fuerunt ex ferro factae quadruplices
7 catenae, et ipsae coriis crudis erant⁴ involutae. Item habuerat protectura eius ex tabulis arcam compactam et confixam, in qua rete⁵ rudentibus maioribus extentis, per quarum asperitates non labentibus⁶ pedibus, facilliter ad murum perveniebatur. Atque ea machina sex modis movebatur: progressu, item latere dextra et sinistra, porrectiones non minus in altitudinem extollebantur et in imum inclinatione dimittebantur. Erigebatur autem machina in altitudinem ad disiciendum murum circiter *p. c.*, item a latere⁷ dextra ac sinistra procurrendo praestringebat non minus *p. c.* Gubernabant eam homines *c*

¹ latitudine *Joc*: altitudine *H.*

² *iii Ro* (*τρίσι Ath*): *iiii H.*

³ pendeat *Mar*: -bant *H.*

⁴ erant *S G*^o: erat *H G.*

⁵ rete (*δίκτυον Ath*) *add. Ro.*

⁶ labentibus *Joc*: habentibus *H.*

⁷ a latere *Joc*: altera *H.*

The ram was 104¹ feet long, with a breadth in the lower part of 15 inches, and a foot thick; tapering towards the head to a foot in width² and a thickness of 9 inches.

6. Now the ram had a beak of hardened iron like those of ships of war, and from it four iron plates, 15 feet long, were fixed to the timber. From the head to the butt of the ram three ropes were stretched 6 inches thick bound to the ends of the ram in the same way as ships³ are held together from the stern to the bows, and these ropes were wound round obliquely, at intervals of 15 inches by another rope which encircled them. The whole ram was enveloped with raw skins above the ropes. The ends of the ropes by which it hung were made of quadruple iron chains, and they also were wrapped in raw skins. 7. The shelter⁴ attached to the ram had a casing made of planks securely fixed, by which when a net of great ropes was stretched (over the roughness of which the feet were kept from slipping) there was an easy access to the wall. The whole machine could be moved in six⁵ ways: in a straight line; right and left. Moreover, the thrust of the machine was directed upwards and let fall at an angle. Now the machine could be raised upwards to demolish the wall to about 100 feet; and by its lateral movements, right and left, it could strike at a length of not less than 100⁶ feet. It

¹ Athen. gives 180 feet.

² Literally, 'in contraction at the top a foot wide.'

³ Acts xxvii. 17.

⁴ *protectura*, probably a technical phrase.

⁵ Backwards and forwards each way; the raising and dropping of the ram is additional.

⁶ The length of 100 feet measures the amount of the wall affected.

habentem pondus ¹ talentum quattuor milium, quod fit CCCCLXXX pondo.

XVI

- 1 DE scorpionibus et catapultis et ballistis etiamque testudinibus et turribus, quae maxime mihi videbantur idonea et a quibus essent inventa et quemadmodum fieri deberent, explicui. Sclarum autem et carchesiorum et eorum, quorum rationes sunt inbecilliores, non necesse habui scribere. Haec etiam milites per se solent facere. Neque ea ipsa omnibus locis neque eisdem rationibus possunt utilia esse, quod differentes sunt munitiones munitionibus ² nationumque fortitudines. Namque alia ratione ad audaces et temerarios, alia ad diligentes, aliter ad
- 2 timidos machinationes debent comparari. Itaque his praescriptionibus si qui adtendere voluerit ex varietate eorum eligendo in unam comparationem conferre, non indigebit auxiliis, sed quascumque res ex ³ rationibus aut locis opus fuerit, sine dubitatione poterit explicare. De repugnatoriis vero non est scriptis explicandum. Non enim ad nostra scripta hostes comparant res oppugnatorias, sed machinationes eorum ex tempore sollerti consiliorum celeritate sine machinis saepius evertuntur. Quod etiam Rhodiensibus memoratur usu venisse.
- 3 Diognetus ⁴ enim fuerat Rhodius architectus, et ei

¹ pondos *H S.*

² monitiones munitionibus *H S.*

³ ex *Ro* : & (et) *H.*

⁴ diogenes *H.*

had a weight of 4000 talents (which makes 480,000 pounds) and was controlled by 100 men.

CHAPTER XVI

ON MACHINERY FOR DEFENCE

1. WITH reference to scorpions and catapults and balistae, and also tortoises and towers, I have explained the details which seemed to me most suitable, stating the names of their inventors, and how they should be constructed. But I did not hold it necessary to write about ladders, cranes, etc., of which the principles are simpler. For the troops are accustomed to make these of themselves. And the measures to be taken cannot be used to advantage in the same way in all places. For there are differences between one mode of fortification and another, and in the military spirit of nations. Thus military engines should be provided in one manner against a bold and rash enemy, in another manner against a watchful enemy, and differently against the pusillanimous.

2. Therefore whoever will attend to these instructions so as to choose from their variety and combine in one provision, will not lack assistance, but will be able to set forth with assurance whatever is necessary to suit occasion and place. Measures of defence, however, are not to be prescribed. For the enemy does not enter on a siege in order to follow our precedents, and his engineering is more often baulked on the spur of the moment by swift and inventive tactics. And this, it is recorded, happened to the Rhodians.

3. Diognetus was an architect of Rhodes, and

de publico quotannis certa merces pro arti tribuebatur ad honorem. Eo tempore quidam architectus ab Arado nomine Callias Rhodum cum venisset, acroasin fecit exemplaue protulit muri et supra id machinam in carchesio¹ versatili constituit, qua helepolim² ad moenia adcedentem corripuit et transtulit intra murum. Hoc exemplar Rhodii cum vidissent, admirati ademerunt Diogneto,³ quod fuerat quotannis constitutum,⁴ et eum honorem ad Calliam⁵ transtulerunt.

- 4 Interea rex Demetrius, qui propter animi pertinaciam Poliorcetes⁶ est appellatus, contra Rhodum bellum conparando Epimachum Atheniensem nobilem architectum secum adduxit. Is autem comparavit helepolim⁷ sumptibus inmanibus industria laboreque summo, cuius altitudo fuerat P. CXXV, latitudo pedum LX. Ita eam ciliciis et coriis crudis confirmavit, ut posset pati plagam lapidis ballista inmissi P. CCCLX; ipsa autem machina fuerat milia P. CCCLX. Cum autem Callias⁸ rogaretur ab Rhodiis, contra eam helepolim⁹ machinam pararet, ut illam, uti pollicitus erat, transferret intra murum, negavit posse.
- 5 Non enim omnia eisdem rationibus agi possunt, sed sunt alia, quae¹⁰ exemplaribus non magnis similiter magna facta habent effectus; alia autem exemplaria

¹ carchesio *ed*: carceso *H*.

² qua helepolim *Joc*: quem lepidolim *H*.

³ diogeni *H*.

⁴ constitutum et *S*: et constitutum *H*.

⁵ galliam *H*.

⁶ pollorcetes *H*.

⁷ heliopolim *H*.

⁸ gallias *H*.

⁹ heliopoliam *H*.

¹⁰ alia quae *Ro*: alique *H*.

received from the state ¹ a fixed salary proportionate to his professional skill and as an honorarium. In his time a certain architect from Aradus, Callias by name, came to Rhodes and gave a public lecture, at which he displayed the drawings of a city wall, and thereupon he set up a machine with a revolving crane which seized a siege engine ² as it approached the ramparts, and removed it within the city. When the Rhodians saw the design, they admired it, and withdrew the appointed salary from Diognetus and gave the post to Callias.

4. Meanwhile King Demetrius, who on account of his stubbornness of mind was named the Besieger, prepared for war ³ against Rhodes and brought with him Epimachus, a famous architect of Athens. And he produced an elaborate siege engine at immense cost both in money and labour. Its height was 125 feet, and its breadth 60, and it was so secured with goatskins and undressed oxhide that it could withstand the blow of a stone weighing 360 pounds, hurled by a balista. The engine itself was 360,000 pounds in weight. But when Callias was asked by the Rhodians to construct a machine to countervail the City-taker and bring it within the walls as he had promised, he said he could not.

5. For not everything can be done by a single method; there are some things which, done on a large scale, produce effects corresponding to those instances which are done on a small scale, there are

¹ Hippodamus seems to have held a similar position at Athens; Vitruvius at Rome. At Athens c. 100 B.C. there was an architect to superintend the temples, *C.I.A.* II. 404.

² *helepolis*, lit. 'City-taker.' Athen. *op. cit.* 7; Diod. XX. 91.

³ 305-4 B.C.

non possunt habere, sed per se constituuntur; nonnulla vero sunt, quae in exemplaribus videntur verisimilia, cum autem crescere coeperunt, dilabantur. Ut etiam possumus hic animum advertere. Terebratur terebra foramen semidigitale, digitale, sesquidigitale. Si¹ eadem ratione voluerimus palmare facere, non habet explicationem, semipedale autem maius ne cogitandum quidem videtur omnino.

6 Sic item in nonnullis exemplaribus videntur, quae² ad modum in minimis fieri videntur, atque eodem modo in maioribus. Id eodem modo Rhodii eadem ratione decepti iniuriam cum contumelia Diogneto³ fecerunt.⁴ Itaque posteaquam viderunt hostem pertinaciter infestum, periculum servitutis, machinationem ad capiendam urbem comparatam, vastitatem civitatis expectandam, procubuerunt Diogneto rogantes, ut auxiliaretur patriae.

7 Is primo negavit se facturum. Posteaquam ingenuae virgines et ephebi cum sacerdotibus venerunt ad deprecandum, tunc est pollicitus his legibus, uti, si eam machinam cepisset,⁵ sua esset. Is ita constitutis, qua machina accessura erat, ea regione murum pertudit et iussit omnes publice et privatim quod quisque habuisset aquae,⁶ stercoris, luti per eam fenestram per canales progredientes effundere ante murum. Cum ibi magna vis aquae, luti, stercoris nocte profusa fuisset, postero die helepolis⁷ accedens,

¹ sic *H.*

³ diognito *H.*

⁵ coepisset *H.*

² quae *Rouse*: quem *H.*

⁴ fecerunt *S^c*: fecerint *H G S.*

⁶ aqua *H.*

⁷ heliopolis *H.*

¹ Vitruvius anticipates the Law of Diminishing Returns, namely, that the increasing of the scale of operations, as in mechanical production, is not followed by a correspondingly increased value in use. *Athen. op. cit.* 7.

other things which cannot follow precedents, but are determined to their own results; but there are some¹ which are promising in sample, but collapse when they begin to increase in scale, as we can perceive from this case: a hole is bored by an auger, half an inch, an inch, $1\frac{1}{2}$ inches in diameter; if we wish in the same way to bore a hole 3 inches wide, our method does not apply; for a hole of 6 inches or more, the notion seems generally inconceivable.

6. Thus also there are things which seem to be done exactly on a smaller scale, and in the same way on a larger scale. By the same rule and the same principle the Rhodians, deceived herein, inflicted injury with violence² on Diognetus. Therefore when they saw the stubborn enemy in the field against them, the danger of enslavement, the engine designed to take their city, the impending desolation of the state, they fell at the feet of Diognetus and implored him to come to the rescue of his native city.

7. First he gave a refusal. Afterwards, when girls and youths of noble birth came along with the priests to intercede, he promised to help on the terms that if he captured the siege engine, it should be his own. This was settled. He made a breach in the ramparts where the machine was to come, and ordered everyone publicly and in private to collect water, sewage and mud and, coming forth, to pour it along channels through the breach in front of the rampart. After a great amount of water, mud, sewage, had been poured down overnight, the next day the siege engine came along; and before

¹ For this sense of *contumelia*, Caes. *B.G.* III. 13, Tac. *Hist.* III. 31.

antequam adpropinquaret ad murum, in umido voragine facta consedit nec progredi nec egredi postea potuit. Itaque Demetrius, cum vidisset sapientia Diogneti se deceptum esse, cum classe sua discessit.

- 8 Tunc Rhodii Diogneti sollertia liberati bello publice gratias egerunt honoribusque omnibus eum et ornamentis exornaverunt. Diognetus eam helepolim¹ reduxit in urbem et in publico conlocavit et inscripsit 'Diognetus e manubiis id populo dedit munus.' Ita in repugnatoriis rebus non tantum machinae, sed etiam maxime consilia sunt comparanda.

- 9 Non minus Chio cum supra naves sambucarum machinas hostes comparavissent, noctu Chii² terram, harenam, lapides progesserunt in mare ante murum. Ita illi postero die cum accedere voluissent, naves supra aggerationem, quae fuerat³ sub aqua, sederunt nec ad murum accedere nec retrorsus se recipere potuerunt, sed ibi malleolis confixae incendio sunt conflagratae. Apollonia⁴ quoque cum circumsedere-tur et specus hostes fodiendo cogitarent sine suspicione intra moenia penetrare, id autem a speculatoribus esset Apolloniatibus renuntiatum, perturbati nuntio propter timorem consiliis indigentes animis deficiebant, quod neque tempus neque certum locum scire poterant, quo emersum facturi fuissent hostes.

¹ heliopolim *H.*

² Chii *ed* : hii *H S G.*

³ fuerat *rec* : -rant *H.*

⁴ appollonia *H* : appollonia *S.*

¹ Polyb. VIII. 6, describes the *sambuca*.

it drew up to the wall, it was engulfed in the wet ground and stuck nor could it get on or get out. Thereupon Demetrius perceived that he had been tricked by the skill of Diognetus, and sailed away with his fleet. 8. The Rhodians, therefore, being freed from their enemy by the artifice of Diognetus, gave him public thanks and decorated him with every honour and distinction. Diognetus brought the siege engine into the city, set it up in a public place with the inscription: **DIOGNETUS DEDICATED THIS TO THE PEOPLE FROM THE SPOILS OF WAR.** In defence therefore not only machines but, far more, are stratagems to be devised.

9. At Chios also, when the enemy had constructed storming-bridges¹ on board ship, the Chians overnight heaped up earth, sand, stones into the sea before the walls. Thus when the enemy next day wished to draw near, their ships grounded on the heaped material which was under water. The ships could neither approach the wall nor draw backwards, but being pierced by burning missiles, they were set ablaze and consumed on the spot.² Again, when Apollonia³ was besieged, and the enemy designed by digging tunnels to penetrate unsuspected within the walls, this was reported by spies to the citizens of Apollonia. They were panic-stricken at the news and their spirits failed them in their lack of resource. For they could not know the time or the place for certain where the enemy were likely to emerge.

¹ Athen., *op. cit.* 9, refers to this same siege in somewhat different terms.

² In Illyria. It was attacked by Philip V in 214 B.C., Livy, XXIV. 40.

10 Tum vero Trypho Alexandrinus ibi fuerat architectus; intra murum plures specus¹ designavit et fodiendo terram progrediebatur extra murum dumtaxat extra sagittae missionem et in omnibus vasa aenea suspendit. Ex his in una fossura, quae contra hostium specus fuerat, vasa pendentia ad plagas ferramentorum sonare coeperunt. Ita ex eo intellectum est, qua regione adversarii specus agentes intra penetrare cogitabant. Sic liniatione cognita temperavit² aenea aquae ferventis et picis de superne contra capita hostium et stercoreis humani et harenae coctae candentis. Dein noctu pertudit terebra³ foramina et per ea repente perfundendo qui in eo opere fuerunt hostes omnes necavit.

11 Item Massilia cum oppugnaretur et numero supra xxx speculatum⁴ agerent, Massilitani suspicati totam quae fuerat ante murum fossam altiore fossura depresserunt. Ita specus omnes exitus in fossam habuerunt. Quibus autem locis fossa non potuerat fieri, intra murum barathrum amplissima longitudine et amplitudine uti piscinam fecerunt contra eum locum, qua specus agebantur, eamque e puteis et e portu impleverunt. Itaque cum specus esset repente naribus apertis, vehemens aquae vis inmissa supplantavit fulturas, quique intra fuerunt, et ab aquae multitudine et ab ruina specus omnes sunt oppressi.

12 Etiam cum agger ad murum contra eos conparare-

¹ specus *H S G*. ² temperavit *E G*: temperaret *H S*.

³ pertudit terebra *H*, ptudit terebra *S*.

⁴ speculatum *H*, specus *ex verbo subauditur*?

10. But at that time Trypho of Alexandria was the architect in charge. Within the walls he planned tunnels and, removing the soil, advanced beyond the wall the distance of a bowshot. Everywhere he hung bronze vessels.¹ Hence in one excavation which was over against the tunnel of the enemy, the hanging vases began to vibrate in response to the blows of the iron tools. Hereby it was perceived in what quarter their adversaries purposed to make an entrance with their tunnel. On learning the direction, he filled bronze vessels with boiling water and pitch overhead where the enemy were, along with human dung and sand roasted to a fiery heat. Then in the night he pierced many openings, and suddenly flooding them, killed all the enemy who were at work there.

11. Again, when Marseilles was besieged² and the enemy drove more than 30 tunnels,³ the inhabitants were on their guard, and made a deeper ditch than the one in front of the ramparts. Hence all the tunnels came out into this. But where inside the wall a ditch could not be made, they dug a moat, like a fish-pond, of great length and depth, over against the quarter where the tunnels were being made, and filled it from the wells and from the harbour. Hence when a tunnel had its passage suddenly opened, a strong rush of water flowed in and threw down the props. The troops within were overwhelmed by the collapse of the tunnel and the flood of water.

12. Again, when a mound was heaped up against

¹ The same expedient is described in the siege of Barca by the Persians, Herod. IV. 200. ² 49 B.C., Caes. B.C. II. 1 ff.

³ *speculatum* cannot be right.

tur et arboribus excisis eoque conlocatis locus operibus exaggeraretur, ballistis vectes ferreos candentes in id mittendo totam munitionem coegerunt conflagrare.¹ Testudo autem arietaria cum ad murum pulsandum accessisset, permiserunt laqueum et eo ariete constricto, per tympanum ergata circumagentes suspenso capite eius non sunt passi tangi murum. Denique totam machinam malleolis candentibus et ballistarum plagis dissipaverunt. Ita eae victoriae civitatum² non machinis, sed contra machinarum rationem architectorum sollertia sunt liberatae.

Quas potui de machinis expedire rationes pacis bellicae temporibus et utilissimas putavi, in hoc volumine perfeci. In prioribus vero novem de singulis generibus et partibus comparavi, uti totum corpus omnia architecturae membra in decem voluminibus haberet explicata.

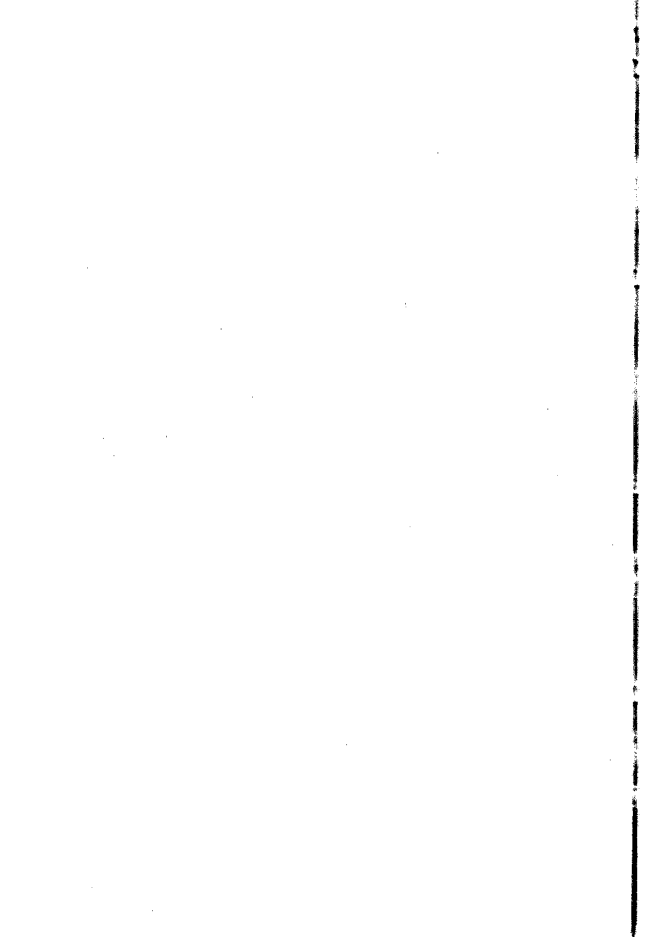
¹ conflagrare *H.*

² victoriae civitatum *idem quod* civitates victrices: *cf. uligines paludum, Tac. Ann. I. 17. 5.*

the walls, and the site was further raised by cutting down trees and laying them there, the citizens shot red-hot iron bars from their balistae and caused the earthwork to blaze up. Again, when the ram tortoise came to demolish the wall, they let down a rope and caught the head of the ram. Then they wound the rope round a drum, using a windlass, and by keeping the ram raised, they prevented it from touching the wall. In the end they demolished the whole engine with fiery missiles¹ and blows from the balista. Thus these victorious cities were liberated not by military engines, but, in face of their employment, by the skill of the architects.

In this book I have fully set forth the mechanical methods which I could furnish, and which I thought most useful in times of peace and war. Now in the previous nine books I have dealt with the other several topics and their subdivisions, so that the whole work, in the ten books, describes every department of architecture.

¹ Caesar refers several times to the use of fire by the besieged, *loc. cit.*



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- Valve**, *assis*, θυρίς, lid covering an opening through which water passes, and yielding one way only, 317
- Vanishing-point**, *centrum*, κέντρον, the point in which parallel lines tend to meet, in perspective, 71
- Verdigris**, *aeruca*, χαλκοῦ ἄνθος, basic acetate of copper, 125
- Vicenariae**, (pipes) made of lead sheets 20 inches wide, 185
- Voussoir**, *cuneus*, σφηνοειδής, wedge-shaped stones of an arch, 55
- Weld**, *luteum*, κρόκος, a kind of mignonette yielding a yellow dye, 129
- Xystus**, ξυστός, a covered colonnade for athletic exercises in winter, 49
- Zodiao**, *zona signorum*, signifer circulus, ζωδιακός, an imaginary belt extending eight degrees on either side of the ecliptic, in which the sun, moon and planets move, and divided into twelve signs named after the corresponding constellations, 11, 241

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¹ This index has been constructed throughout by reference to the text of *H.* This circumstance and the special reference to craftsmanship has involved at least a hundred variations from the Index of Rose and Müller-Strübing (ed. 1867), an edition which, following Mr. Krohn, I treat as the vulgate.

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NOTE ON THE ILLUSTRATIONS

The illustrations are intended, in the spirit of Vitruvius himself X. viii. 6, rather to indicate the principles on which machines are constructed than to exhibit the details of such construction which, he says, can only be understood in the presence of the machines themselves. The attempted restorations of the water-clock Pl. N, and the water-organ Pl. R are to be understood in this sense.

Plate K requires a further note. The problem of the Mesolabium is to find the proportion between the sides of two cubes one of which has double the content of the other. This is solved by taking two mean proportionals. The analytic solution is given in a note, p. 206.

The Mesolabium solves the problem geometrically.

It consists of three square frames with diagonals, moving in grooves so that MFGN can pass behind AEFM, and NGHQ, behind MFGN. Let QH be bisected at D.

Then the second frame is made to slide under the first, and the third under the second in such a way that the points at which the diagonals disappear, B and C, are in a straight line with AD. Let the line AD and the line EH be produced until they meet at K. By the similarity of the triangles, it may be shown that $AE \cdot BF \cdot CG \cdot DH$ are in continued proportion; hence if $AE = 2DH$, $BF^3 = 2CG^3$.

The Cheirotometon was represented in a drawing—*quo scribitur*—and had reference to the impression made by a ring. We have seen how the perspective treatment of stage scenery revolutionised the art of painting. It is probable therefore that the cutting of intaglios with reference to perspective projection, explains the revolution which produced the masterpieces of the fifth century. The phrase 'cheirotometon' or 'hand-cut' is peculiarly appropriate because the

NOTE ON THE ILLUSTRATIONS

diamond-point, as contrasted with more mechanical tools, was used with greater freedom and revealed the touch of the artist.

Middleton, *Ancient Gems*, app. xxvi, refers to the impossibility of representing a rounded surface in a plane projection. Hence, some such diagram as Pl. K, fig. 3, would guide the artist. Let B . . B represent the plane containing the surface of the stone to be cut; and A . . A a line perpendicular to this plane. Let I . . I represent the depth of the intaglio; and S . . S the raised surface of the impression. Let C be taken as the vanishing-point of the intaglio. As a matter of fact, the subject of an intaglio is so near the imaginary spectator that a vanishing-point can usually be left out of account. There are exceptions. The chair on a gem of Dexamenos is rather absurd, Middleton, *op. cit.*, fig. 11. It clashes with the perspective of the figure. Hence a vanishing-point is sometimes necessary.

In addition to the vanishing-point which is the same for the intaglio and for the impression, there is the more difficult matter of adjusting the depth of the intaglio to the desired impression. As the eye moves from the vanishing-point, the corresponding points on the intaglio appear nearer to the centre of the picture, than the points on the actual impression. This appears from the dotted line R which indicates the ray from a point in the intaglio. The horizontal line drawn from the end of R shows the corresponding point in the impression, which is more distant from the centre, than the ray from the intaglio.

For Granger's belief that the Pantheon was a huge sundial, see *Journal R.I.B.A.*, 26 Nov. 1932. It is not credible—cf. D. S. Robertson, *Class. Rev.*, 1934, 229.

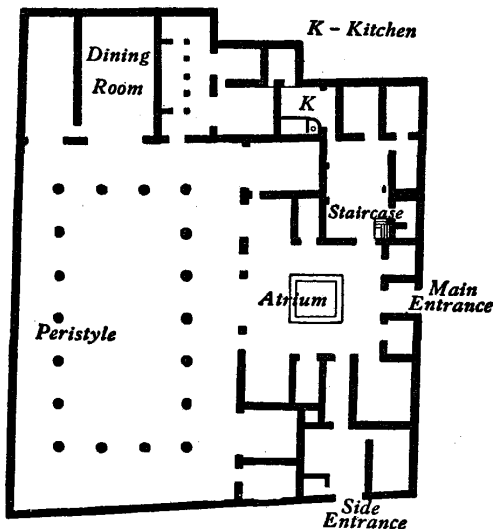
It is possible to form some idea of the automata constructed by Ctesibius and others. Plate M is based mainly on Barbaro *Vitruvio* A.D. 1584, p. 433. The motive power is supplied by an inverted bowl resting on water which rises or falls by a supply through a funnel (not shown), regulated as in the water-clock, Pl. N. A pull in the opposite direction is exercised by a bag of sand. It will appear that a small turn of the axle will cause a considerable movement of the vertical toothed wheel, and this movement is transmitted by the horizontal toothed wheel and is magnified in the large wheel turning on the same axle. A figure rising, as shown, from the large

NOTE ON THE ILLUSTRATIONS

wheel, carries a pointer which, by some use of wedges, is kept in contact at its upper end with the pillar. The pillar by its excentric position in regard to the large wheel, varies the distance by which the figure in its revolution, is separated from the pillar. In this way, the figure at its greatest distance points to the bottom of the pillar, and as it approaches nearer the pointer attached to it rises towards the top of the pillar, thus indicating the markings on the pillar. The difficulty of adjusting the pointer to the fixed pillar by wedges, suggested an alternative arrangement by which not only the figure but the pillar is made to revolve, IX. viii. 7. But the principle of the mechanism is the same. The reader must again be warned that precision of detail is not to be expected.

Plates O, P, Q, are taken from the small Junta edition of Vitruvius of 1522, and are due to Fra Giocondo. They illustrate the principles of the Pulley, the Tympanum, and the Water-screw.

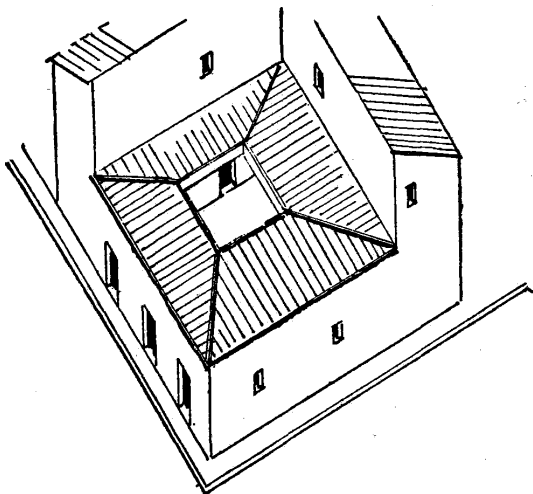
The attempted restoration of the Water-organ, Plate R, owes something to the valuable illustration of W. Schmidt, *Hero*, I, p. 500. But as will be seen on comparison, my own figure is simplified.



PLAN OF HOUSE

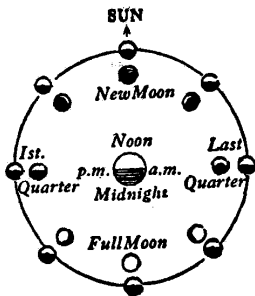
Domus Vettiorum, Pompeii.

Book VI. III. 3



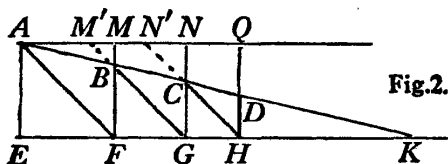
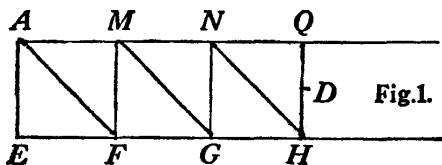
DISPLUVIATE ROOF

Book VI. III. 3.

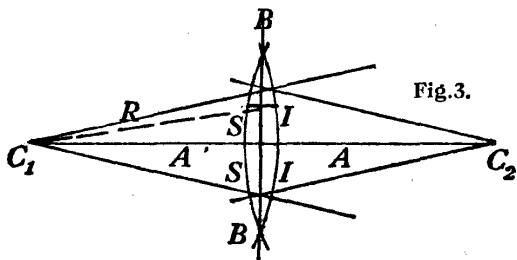


PHASES OF THE MOON

Book IX. II. 1.

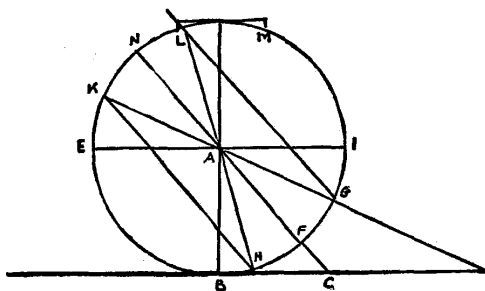


MESOLABIUM



CHEIROTOMETON

PLATE L.



ANALEMMA: LATITUDE OF ROME

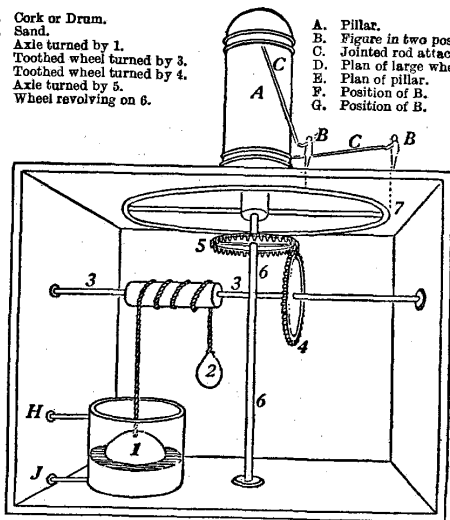
Book IX. vii. 1 ff.

AB. Gnomon.
BC. Shadow.
EI. Horizon.

CFAN. Equinoctial Ray.
GAK. Winter Solstice.
HAL. Summer Solstice.

1. Cork or Drum.
2. Sand.
3. Axle turned by 1.
4. Toothed wheel turned by 3.
5. Toothed wheel turned by 4.
6. Axle turned by 5.
7. Wheel revolving on 6.

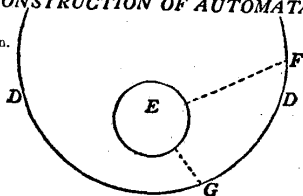
- A. Pillar.
- B. Figure in two positions.
- C. Jointed rod attached to B.
- D. Plan of large wheel.
- E. Plan of pillar.
- F. Position of B.
- G. Position of B.

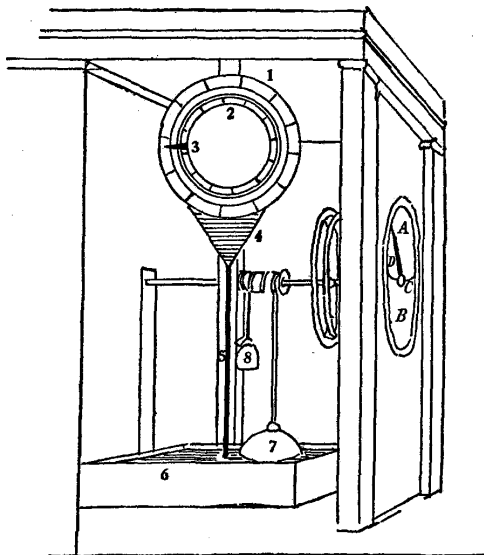


CONSTRUCTION OF AUTOMATA

- H. Inlet to cistern.
- J. Outlet.

Book IX. viii. 5.



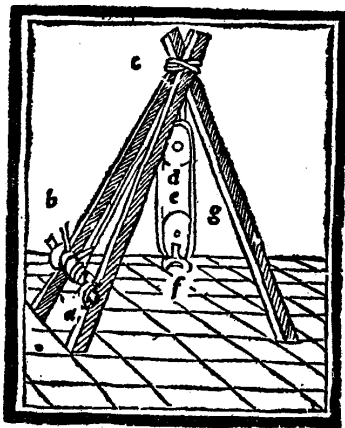


WATER-CLOCK OF CTESIBIUS

Book IX. viii. 8.

- | | |
|---|-----------------------|
| 1. Outer fixed circle of signs. | 7. "Cork" or drum. |
| 2. Inner movable circle of months. | 8. Sand. |
| 3. Point moving with inner circle. | A. Hours of daylight. |
| 4. Cistern receiving water from rotary valves of 2. | B. Night hours. |
| 5. Pipe delivering into 6. | C. Dividing line. |
| 6. Main cistern. | D. Finger of clock. |

PLATE O.

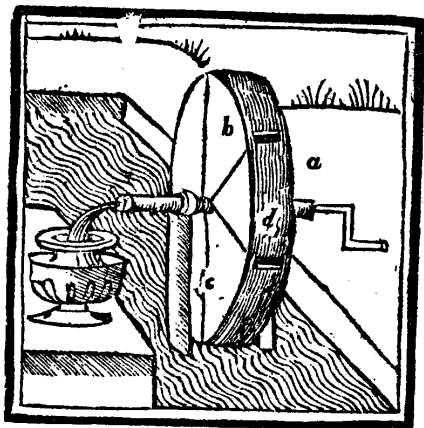


PULLEY.

Book X. ii. 1 ff.

- a. Windlass.
- b. Socket of windlass.
- c. Brace.

- d. Upper block.
- e. Lower block.
- f. Pincers.



TYMPANUM

Book X. iv.

a. Axle.
b. Tympanum.

c. Upright.
d. Opening.

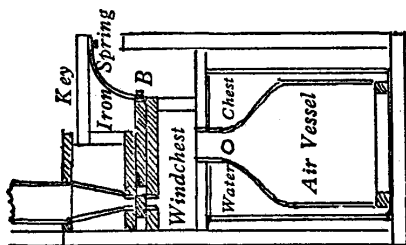


WATER-SCREW

Book X. vi.

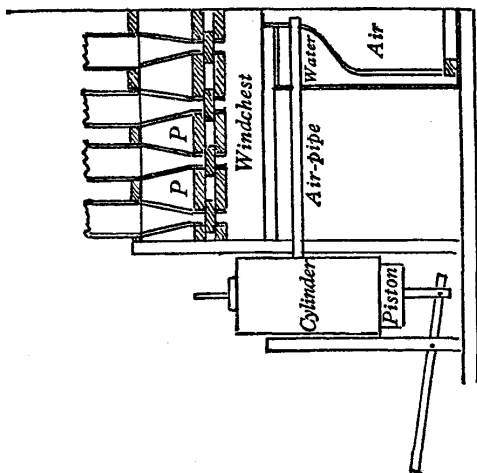
a. Screw.

b. Upright in which screw turns.



CROSS SECTION

Book X. viii.



LONGITUDINAL SECTION

WATER-ORGAN

P. Top Board.

B. Sliding bar.

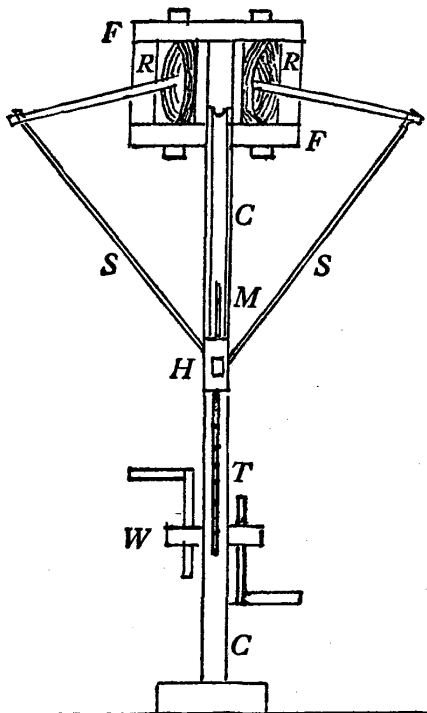


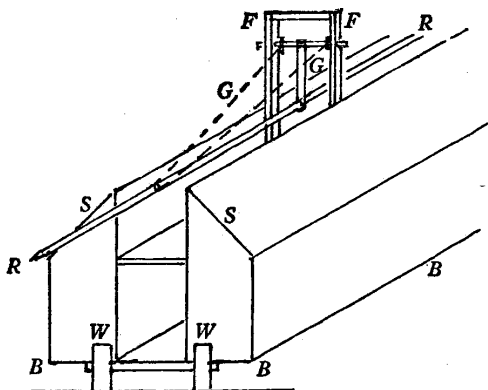
DIAGRAM OF BALISTA: BACK ELEVATION

BALISTA

Book X. xl.

C. Channel inclined 45°.
F. Frame.
R. Ropes in tension.
W. Windlass.

S. Bowstring.
M. Missile.
H. Hook to release bowstring.
T. Rope tightened by windlass.



FRONT ELEVATION AND ISOMETRIC PROJECTION

TORTOISE OF HAGETOR

Book X. xv.

F. Frame.
G. Guiding ropes.
R. Ram.

B. Base.
W. Wheels.
S. Sloping roof.

